US Army Corps of Engineers
Engineer Topographic Laboratories

Fourth National MOSS Users Workshop

May 18 - 21, 1987
Denver, Colorado

Proceedings

Fourth National MOSS Users Workshop

Compiled by

U.S. Department of the Interior
Bureau of Indian Affairs
Lakewood, Colorado 80226

July 1987

INTRODUCTION

The Fourth National MOSS Users Workshop was hosted by the Bureau of Indian Affairs and Colorado State University at the Stouffer Concourse Hotel in Denver, Colorado on May 18-21, 1987. Over 125 participants attended representing Federal and state agencies, universities, and the private sector.

The Map Overlay and Statistical System is approaching a turning point in its development. The conversion to the Prime operating system has pointed out serious deficiencies in the software code and its structure, the data structure itself, and the user interface. Dr. Armando Guevara, team leader for ESRI in the software conversion, provided an overview of many of these problems. The charge to the attendees was clearly to evaluate MOSS and the direction its development is to take in light of these system problems.

Quite clearly, MOSS's functionality has been successfully demonstrated. It has assisted managers in making resource management and land use decisions. It is quite capable of producing high quality cartographic products. Twenty-one papers were presented detailing software development and system applications, many of which are used on a day to day basis.

The evaluation required of MOSS, then, is not whether it can meet certain functionalities, but whether it is a system of adequate sophistication and flexibility to meet a vast majority of needs and, if not, what is required to make it such a system.

The primary topic of discussion during the three workshop sessions also centered on the direction MOSS must go to meet user needs. The User's Session addressed the need for a firm commitment from Management to support and develop the system. The System's Session directly attacked shortcomings in the software requiring attention on a long and short term basis. The Manager's Session charged the Users and Systems Groups with providing them with a well defined package of needs and suggestions.

Over the course of the next several months, the User, System, and Manager groups will meet, continuing to address the problems associated with bringing MOSS up to date relative to GIS technology as a whole.

Herein are the proceedings of the technical sessions, including copies of each presenter's paper, a list of those attending, and a summation of topics of discussion from the group sessions.

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Work Group Summations

Section 1

FOURTH NATIONAL MOSS USERS WORKSHOP

SUMMARY OF MANAGEMENT WORKGROUP SESSION

MAY 21, 1987

1.0 INTRODUCTION

This document presents a summary of the results of the meeting of MOSS MANAGERS during the 4th National Moss Users Workshop. The papers presented at the workshop clearly indicated that the MOSS family of software continues to be utilized on an extensive basis by the GIS community. However, lack of software support and development emerged as a common problem among all users. Reports received from the Users and Systems workgroups confirmed the fact that, by and large, the User community could not rely upon MOSS being upgraded or maintained properly. Originally developed and supported by USFWS, subsequently supported and upgraded by the BLM, MOSS has become a travelling stepchild. Furthermore these agencies have never received proper fiscal reimbursement from "Users" to help defray the high cost of keeping the software current. In short, a mechanism has never been implemented which assigns lead responsibility to an agency for MOSS, and then provides through interagency agreements funding from the user agencies to the responsible agency to defray the costs. From the previous 3 workshops it was evident that getting suggestions for software improvement and criticisms of the software from agencies was easy. The rub was and remains whether agencies are willing to pay for what they want/get. As a result, it was concluded that the proper action for the management team to initiate was to create a joint team of users, systems, and management with the specific assignment to first scope out the requirement, secondly to obtain agency concurrence through funded agreements, and finally to implement the infra-structure within DOI.

2.0 OBJECTIVE

The management team defined its objective as follows:

To create an architecture within DOI which establishes a lead MOSS agency, provides for financial support to the agency, and insures continued and long term commitment by DOI agencies to the architecture.

In order to accomplish this objective an action plan was developed. This plan is outlined in the following section.

3.0 ACTION PLAN

1. Establish a MOSS Configuration Management Team (MCMT) of user, system, and management personnel to facilitate the development and implementation of the MOSS ACTION PLAN. In addition, the MCMT shall also continue in existence after the development of the plan to oversee the plans implementation, and to then serve as the oversight team for continued operations. Mr. Claude Christensen (FWS) and Mr. Bill Bonner (BIA) were appointed to serve as interim co-chairmen for the MCMT.

2. Require DOI agencies to assign appropriate personnel to MCMT to participate in the development and implementation of the architecture.

3. Develop a comprehensive plan which is adjudicated through the agencies, and then approved through signature. This plan must provide funding, system standards, personnel commitment, and data standards.

4. Draft charter for MCMT. Utilize existing cooperative strategy charter. Mr. Claude Christensen of FWS was assigned this task.

5. Task the User Workgroup to compile, describe, edit, and prioritize their requirements. This tasking carries forward the requirement to include/consider all previous input as obtained in the preceding 3 conferences. Both management and systems representatives are to be assigned to this task with the User having the lead responsibility. This latter requirement is intended to insure vertical and horizontal communications.

6. Task User Workgroup to recommend basic or core system which is adjudicated by the agencies.

7. Task the Systems Workgroup to scope the short term fixes which are needed for MOSS. Further task them to scope the requirement as input by the user team from steps 5 and 6. Scoping is to include all costs (ie, annual, operations, start-up, development, etc.) as well as, timelines.

8. Task the Systems Workgroup to prepare a software/system development plan which considers impacts on users, and agencies.

9. Convene the MCMT no later than (NLT) August 1987 to evaluate the input from the user and systems workgroup tasks. Determine course of action, prepare detailed MOSS Action Plan, and report back to user and system workgroups.

10. Obtain review of MOSS Action Plan from user and system workgroups NLT September 1987.

11. Present MOSS Action Plan to Directorates NLT October 1987. This presentation shall include executive summary, required resources (funding and personnel), required MOU and IAGs, coordination with OIRM, and coordination with IDCCC.

12. Obtain approval of Directorate and implement plan. This action shall include the requirement for each agency representative to secure the transfer of appropriate funding to the designated lead agency, and the authorization for their own staffing requirements. In addition, the MCMT shall be prepared to assist the lead agency in implementing any contractual requirements which are necessary for the success of the MOSS Action Plan.

13. In role as the oversight committee, the MCMT shall monitor the progress of the implementation of the plan and regularly report back to the system and user workgroups, as well as OIRM and the IDCCC, on progress. The MCMT shall meet quarterly to insure that the MOSS Action Plan is accomplished.

4th MOSS USERS WORKSHOP

DENVER, COLORADO

MAY 18-21, 1987

RECOMMENDATIONS FROM SYSTEMS WORKGROUP DISCUSSIONS

INTRODUCTION

MOSS has significant problems which make it difficult to maintain and enhance. For this reason, attempting to address particular problems with particular commands often leads to less than perfect solutions. It is important to improve MOSS by addressing its most fundamental problems which are limiting its reliability, performance and maintainability. As MOSS moves to more computer architectures such problems become greater. We have reached the point where continued support and development of MOSS will become virtually impossible without some changes to both MOSS and MOSS maintenance procedures.

MOSS has arrived at a turning point in its evolution. The recent porting of MOSS to the Prime environment has pointed out some specific areas of machine dependencies and general problems in the code. Some of these problems have been addressed as part of the conversion. Others are being dealt with. Still others remain to be addressed. The Systems Group has discussed MOSS and what is required, based upon our experience and newly available information from the conversion, to assure a future for MOSS while avoiding a complete rewrite and using as much as possible of existing code.

OBJECTIVES

The major objectives of the work we feel is necessary are as follows:

Improve the reliability and performance of the software.

Improve the maintainability of the software.

Focus on the Prime environment but develop a set of code which is supportable on multiple architectures. This will address the question of support on many computers (Prime, Data General, Vax, PC, plus others in the future).

Accomplish some ground work which will provide for a more promising future for MOSS.

MOSS REQUIREMENTS

The following tasks could be accomplished in the short to medium term and go far toward accomplishing the above objectives. Users and managers must realize that not all of these tasks will result

in immediate returns to the user community but will significantly improve the maintainability of the code and make responsive software maintenance more realistic.

For the nearly one half million lines of code in MOSS and family the following should be done (in order of priority) as part of or after the Prime version release.

Define COMMON blocks consistently.

Go to 32 bit coordinate storage. (Short Term, Improve Performance) *

Isolate/Consolidate I/O, Graphics, Parsing, Prompting, Error Processing. *

Implement I/O channel manager with strict Read/Write privileges on file OPEN.

Minimize use of Command Languages and Operating System specific directory, ACL, and searchlist features.

Change Disk Arrays to utilize Virtual Memory. *

Remove duplicate data from data files (POLYGON.DH, POINT.DT, MASTER.DH)

Implement other code changes as recommended by ESRI.

Develop, implement and enforce a strict DOI-wide procedure for check out, modification, and distribution. Libraries for tasks such as I/O, Graphics, Parsing, Prompting, and Error Processing should be developed and distributed to software developers only as link modules so that strict controls can be kept on low-level source code modification. Users should be made aware of problems associated with making local modifications. The government should strive toward making a single government employee responsible for a single program (MOSS, MAPS, ADS, AMS, COS, etc.) to keep the management of software development realistic. Funding should be a priority for these positions so that continuity is maintained. This person should be a technically involved staff member.

NOTE: Those items footnoted with a * will result in immediate returns to the user in reliability, consistency, or performance of the software.

IMMEDIATE ACTION ITEM

A very rough estimate of what will be required to accomplish these tasks is 4-5 high level programmers for 4-5 months. However, we strongly suggest that each agency contribute a single technical person for ten hours per week during June. These people will further develop these requirements and develop costs estimates for each item so that information will be available by

July 1 for budgeting purposes. Some of these tasks which are already funded by BLM must be identified. Based upon this work, agencies will, for the first time, have detailed information about the cost of correcting these problems with MOSS.

FUTURE MOSS DEVELOPMENTS

The above tasks will prepare for the accomplishment of several long term tasks which would be desirable future developments for MOSS. However, even without the accomplishment of the long term tasks, we feel the short term tasks will significantly improve the reliability, performance, maintainability and supportability of MOSS.

The long term tasks are:

Move toward graphics standards (GKS ?).

Develop, implement and enforce DOI coding standards.

Implement an Arc-Node data structure.

Implement an RDBMS.

TIME FRAMES

The following major categories were discussed.

Short term: the Prime version release.

Medium term: any remaining items from the eight listed by the Systems Group plus fixes identified by the User Group.

Long term: RDBMS, Arc-Node data structure, graphics standards, coding standards, etc.

FOURTH NATIONAL MOSS USERS WORKSHOP

Summary of Users Workgroup Session
May 20-21, 1987

I. SPECIFIC COMMENTS BY AGENCY USERS

1. Bureau of Land Management (BLM)

The recent merger between Automated Land and Minerals Record System (ALMRS) and GIS has resulted in an emphasis on ALMRS and a shift in programmers to ALMRS.

Regarding MOSS software, there are still the old problems that need to be fixed; new and different problems with the BLM 87.01 version; and less people available to fix them. While several problems have been addressed, and two persons are being assigned to work on MOSS (George Fuller and Bill Turner, Autometric, Inc), there are not sufficient terminals available.

There is a formal mechanism and procedures to get fixes/releases out to other users, but no one person is currently designated to handle this task.

Support for MOSS on the Data General minicomputers may be phased out at the BLM-Denver Service Center (DSC) unless major problems at the BLM-Colorado State Office require support from the DSC.

Summary: BLM needs more people and equipment to do the job of fixing daily problems; providing telephone support for the field personnel; testing the software on the Prime; and coordinating release versions, etc.

Current Plan: The effort to support and test MOSS on the Prime will begin next week, with an initial release expected in July 1987. Work will continue through the Fall, with a final release in late FY87 or early FY88.

2. U.S. Forest Service (USFS)

Nicolet National Forest, WI:

The Forest Service currently has a subscription service with Autometric, Inc. for support and software releases and are satisfied with the level of support provided to date. The Rhinelander, WI office already has the 4100 and 4200 Tektronix software enhancements on its DG computer.

USFS, Region 8, Atlanta, GA:

The Region 8 Office currently has no inhouse software support or subscription service and relies on the FWS National Ecology Center (NEC) and BLM-DSC for telephone support when needed. Its short term plans are to continue to rely on FWS and BLM for support on the DG; if support becomes unavailable in the future, they may have to look at using other systems to accomplish their work.

3. Department of Energy (DOE)

Los Alamos National Laboratory, NM:

The Los Alamos National Laboratory currently has a subscription service with Autometric, Inc., and is pleased with the support provided to date. No inhouse support capability is planned for the future. Although MOSS will continue to be used on the DG, and funding for several fixes to the DG version was planned, there is no longer sufficient justification due to internal decisions and plans to use Delta-Map software.

4. Bureau of Indian Affairs (BIA)

The BIA is using the BLM-DSC Hotline service for MOSS support and FWS-NEC for AMS support. Inhouse support is planned for MOSS on the Prime and the BLM Hotline service will continue to be a source of daily support to BIA users.

5. U.S. Fish and Wildlife Service (FWS)

National Ecology Center (NEC), Ft. Collins, CO:

The FWS-NEC currently has inhouse support for AMS and provides outside support to several agencies. There is virtually no support for MOSS or COS software on the DG or Prime, and none is planned for the future. Limited testing of AMS on the Prime is being conducted at the NEC, but responsibility for formal testing and release of AMS for the Prime is with the FWS National Wetlands Inventory Center (NWIC), St. Petersburg, Florida.

National Wetlands Research Center (NWRC), Slidell, LA:

The FWS-NWRC currently has limited inhouse AMS/MOSS/COS support for both the DG and Prime computers; however, there is not sufficient personnel to maintain support for both computers. Software support is currently provided to several outside users.

FWS Region 5, Annapolis Field Office:

The FWS Annapolis Field Office currently has a subscription service with Autometric, Inc., and is running AUTOGIS on a VAX computer as the first BETA test site. The AMS is also being used for inhouse digitizing tasks.

6. State of Louisiana, Department of Natural Resources (DNR).

The Louisiana DNR currently has a subscription service with Autometric, Inc., but depend on the FWS-NWRC for most of their support.

II. USER WORKGROUP CONCERNS/CONCENSUS

1. MOSS Software.

- Funding must be available to get MOSS working on the Prime, at least to the level that it's working on the DG's. This should occur since BLM is authorizing FY87 funding for contract personnel support.

- Funding must become available to get the fundamental problems identified by ESRI fixed, to make MOSS a better system, provided that the old problems identified in previous years are also fixed in the Prime version (e.g., build an arc/node structure). If these are not addressed, it may not be worth sinking additional funds into MOSS. There must be a commitment by management for a "modern" GIS.

2. MOSS Support

There is currently no coordinated effort in any agency to provide GIS support. Each agency is getting by, using whatever means or methods necessary to get its job done. This makes it impossible to achieve interagency or Department-wide coordination for GIS support.

- The current lack of systems support in each agency will most likely continue, making the initial goal of centralized GIS support within DOI virtually impossible. Either we go on "status-quo" or initiate an effort to obtain centralized support via a DOI-wide procurement. The Department is currently investigating the possibility of a DOI Digitizing Services Contract and there is talk of a DOI procurement for a second GIS. Why not include GIS support as well? This would force agencies to commit funding for software support. If they cannot, then they are on their own; we cannot continue to expect one or two agencies to support all DOI agency users, as well as users in other Departments. This places an unfair burden on these agencies, which essentially donate personnel time and computer resources for GIS support without cost reimbursement.

  The current transition from DG to Prime will require more systems support, not less. MOSS is now running on DG, Prime, VAX and PC computers. The Government must commit to GIS software research and development; user support; system maintenance; documentation; and upgrades.

- Support must be maintained for the DG versions of MOSS, at least for the next few years.

3. Agency Coordination on Software Status and Development Needs

- There is currently no focal point in any agency for assistance in obtaining current GIS software releases and/or documentation. A person from each agency should be designated to coordinate requests for software and subsequent distribution. This should lead to unified versions, at least within each agency and hopefully throughout DOI.

- There is currently no formal mechanism for obtaining information on the GIS software status. An agency bulletin board on a dedicated micro or use of COMPUSERVE would be useful to GIS programmers and users for reporting problems, documenting fixes, reporting on software status, etc.

- A MOSS Users Group must be created in order to provide input on MOSS problems, development needs, etc., to Washington Office Management staff.

- A procedure to allow users ready access to data captured by other agencies must be established.

MOSS Software Conversion Session

Section 2

MOSS PRIME Conversion Project

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MOSS 4th User's Conference
Denver, Colorado
May 19, 1987

1.- Introduction

The objective of this software conversion effort was to convert the various geoprocessing software programs, i.e. MOSS, WAMS, AMS, MAPS, COS, COS3, PROJECTION, REFORM and PENPLOT, from the Data General computer to the PR1ME computer. The PR1ME implementation was required to run as well as the Data General.

This effort did not require that the software be enhanced, nor that problems in execution on the Data General be cured in the process of conversion on the PR1ME.

In order to meet the objectives of the conversion effort, it was necessary to establish a cycle of test requirements to measure the success of the conversion.

Six months was the time frame to do the conversion.

2.- Conceptual Overview

The basic strategy in accomplishing the conversion was to install government's software on the Data General computer at the Environmental Systems Research Institute (ESRI) in Redlands California. The resulting installation established the "baseline" conditions for software execution and performance (and for acceptance and testing by the government) against which the converted code on the PR1ME were to be tested and compared.

The conversion process would then consist in making one-to-one substitutions between software concepts and constructs on the Data General and corresponding concepts and constructs on the PRIME.

The substitutions would be defined by a growing set of rules which were expected to drive the conversion process itself. In this sense, the conversion process would chiefly consist of discovering what these rules were, documenting them, and then applying them to the Data General code versions in order to create new PRIME code.

Thus the conversion process was not only going to produce new source code but also this set of rules which, embodied in PRIME's CPL and FORTRAN programs, would create a software tool to assist in the actual conversion process. In this sense the conversion was to be "rule based" and supported by command language procedures (CPL) which would filter source code by applying the rules to it.

The success of the conversion was to be measured by (1) successfully compiling and binding (linking) the converted code and then (2) executing the code as to meet the government's defined test and acceptance criteria.

2.1.- Approach to Accomplishing the Objectives

ESRI's initial approach to accomplishing the objectives of the software conversion involved the following principles:

a) Placing the effort in the hands of ESRI's most qualified software programming and software support staff, combined with staff augmentation especially for this project.

b) Analyzing of the overall structure of the software and its file structures prior to deciding how to proceed with the software conversion effort.

c) Establishing a growing set of rules to govern the conversion, so that conversion would be increasingly automated as the project progresses.

d) Using a designated software librarian and test/acceptance sets to maintain control of the conversion process.

e) Nominating a single project manager in overall control of all aspects of the conversion, with most capable and experience staff assigned to MOSS, with other staff assigned to more recent and better documented software.

f) Implementing constant information flow between working groups to insure that new, valid conversion rules were adopted as quickly as possible.

g) Testing converted code incrementally to insure that each progressive step is succesful before proceeding.

h) Limiting the conversion to the absolute minimum code changes to maintain current documentation as much as possible and avoid introducing new problems into the software systems.

2.2.- Summary of Plan

The following basic steps outline the conversion plan:

1. Obtain the Data General version of the software and install it on ESRI's Data General machine. This was to provide the "baseline" for comparing with the converted software on the PRIME computer.

2. Obtain the set of acceptance test procedures from the government and run these on the Data General version of the software to insure that the software on the Data General can meet the acceptance tests, and to define the "baseline" in terms of acceptance.

3. Determine the initial correspondence between the Data General code and PRIME code regarding file structures, subroutine libraries and

software organizational concepts.

4. Based on these initial correspondences, and the identified structure of the software, divide the code into discrete packages and assign these to the programmers.

5. Based on the initial correspondences, begin the creation of a set of rules to guide the actual code conversion process.

6. Generally working in parallel, for each individual "package" of code:

a) Load the package on the PRIME;

b) Compile with FORTRAN 77;

c) Substitute code until compile problems are solved;

d) Load and execute the PRIME code until the acceptance test criteria are met.

7. Deliver PRIME version (FORTRAN 77) of software source code.

2.3.- The reality of time

At the time of assuming responsibility for the conversion effort a full concensus on the rule layout for the manual conversion of the software had not been reached. This affected the conversion of functions not handled by the automated tools. This included aspects of multitasking, DG linkage environment, PUSH/POP at OS level and internal octal handling (characters, constants). The first re-scheduling step was to design these functions so they could be appropriately emulated on the PR1ME.

After three months of ongoing conversion efforts most of the code had been compiled and links were being completed and verified. For programs that could be executed we found they did not work because the code could not be made operational "as is". Mixture of types was a serious problem in FORTRAN 77 (octal and decimal equivalent comparisons were failing); file handling was not documented for some programs (some files on the base line system were constructed several years ago, yet were used by programs). The assumption that the code could be converted without understanding what it did did not hold up; code had to be inspected and understood in many cases.

The automated conversion tools took care of the bulk of the conversion. However, in several instances it was necessary to inspect the code for FORTRAN machine incompatibilities that could not be detected until run-time.

The fact that a program compiled and bound was no gurantee that it would execute properly (per DG). Part of the main complication was

that the MOSS family of programs was based on a integer short architecture, fortran 66 (not the standard version), fortran 5 (D.G. version) and a potpourri of fortran 77.

Added to the above, it had a lack of consistency in communications protocol, an inconsistent and unorthodox mixture of data types, and duplication of functions at the software data base level.

Based on the experience of converting a well defined system like ARC/INFO from the PRIME to the VAX environment (with less than 150,000 lines of code), I immediately realized that the time estimates needed to be re-evaluated for this conversion.

As a simple academic exercise I looked at the MOSS program first. The MOSS subsystem had 89 programs and 94422 lines of code (701 routines). Producing a program a day (which is not realistic) would give a delivery date of May 31, 1986.

Since I had found that parts of the conversion could not be done without actually modifying the code (which is like writing new code), and if we added to this the lack of knowledge in some of the areas of file structure and communications protocol used in the MOSS family of programs (thus having the task of deciphering black boxes), I found the time table leading to 16 hour/days for the next 5 months.

I wanted to think that we could produce a production curve of this type:

```
  454,288 I                *
          I                *
  Lines   I              *
   of     I            *
  Code    I           *
          I          *
          I***********
          ------------------------------------
                     TIME
```

yet I had strong doubts after inspecting the code that this was possible.

2.3.1.- Project Plan Revisited

At the time the tasks were distributed in the following way:

Team Member	Sub-system	Lines of Code	Executables	CLI
1	ADDWAMS	2454	1	0
	AMS	95321	80	476
2	COLOR	1622	3	0
	COS	16937	14	35
	MAPS	37928	21	2
	PENPLOT	5518	1	0
	REFORM	15071	22	22
	START	1735	0	1
	UTILITY	6840	0	0
	BYTE	972	0	0
3	ADS	45024	50	217
	COS3	35296	2	5
	GKS	10785	4	3
	PLOTLIB	3119	0	0
	PROJ	11784	1	1
	PROJ.NWI	9046	1	1
	SET	2832	0	0
4	TEKLIB	4372	0	0
	TEKTRONIX	2163	0	0
	ZETA	1729	0	0
	BLMZETALIB	4638	0	0
	CALCOMP	1672	0	0
	GERBER	168	0	0
	HEWPACK	3499	0	0
5	MOSS	93052	89	3

TOTAL: 289 programs (441,962 lines) 766 CLI (12,326 lines)

The basic tally of programs was 289 FORTRAN and 766 CLI. Average number of lines per FORTRAN program was of 1529.28 and for CLI was 16.09. Based on a four person team there was an average of 72.25 programs/person and 191.5 clis/person. Based on an 8 hour day, 4 week month (not counting week-ends), the following chart expresses the time table for the conversion of one program-per-day/1529 lines of code-per-day:

SCHEDULE I

```
I========> (third week of april)
I
-J--F--M--A--M--J--J--A--S--O--N--D--J--F--M--A
         1987                       1988
```

To commit to this schedule it was necessary to have every day a program compiled, linked and running. Given the status of the code (that it required manual fixing and re-writing) I found this schedule unrealistic.

Estimating a program every two days (765 lines of code-per-day) the chart looks like this

SCHEDULE II

```
I===================> (first week of August)
I
-J--F--M--A--M--J--J--A--S--O--N--D--J--F--M--A
         1987                       1988
```

I felt this was a feasible schedule if the conversion curve went as outlined above.

Finally, a schedule of a program every three days (510 lines of depured-code-a-day) looks like this:

SCHEDULE III

```
                         (first week of November)
I=============================>
I
-J--F--M--A--M--J--J--A--S--O--N--D--J--F--M--A


         1987                       1988
```

As can be noted, none of this schedules, although realistic, met the contractual delivery date of April 3, 1987.

The next approach was to reduce the conversion load per conversion team member by adding three additional experienced senior programmers to support:

a) All CLI -> CPL conversion.
b) Testing of low-levels on PRIME.

c) Support ADS conversion-capture phase.
d) Support AMS conversion-digitizing and data base functions.
e) Support COS, COS3 and GKS

2.3.2.- What to do

Unforseen factors were delaying the MOSS Conversion Project. I found that with current trends the project would not be completed by April 3, 1987. There were two major issues:

a) The need to do functional replacement of code by having to re-write a given routine. This required understanding what the routine does.

b) The amount of code required to be converted.

The above issues could be resolved by:

a) Extending the delivery date to second week of August 1987

Or

a) Add three senior programmmers.

The latter solution was chosen. It was necessary however to get prompt action from the government whenever documentation was required on file structures. Conversion could not proceed if system files had no documentation (how they were created, what they contain, how they are used and what programs use them). Time scheduled could not be maintained if the conversion had to be stopped to determine what a given piece of software does or the identity use of a file structure.

For the purpose of driving the conversion process, a series of calling chart schemas were assembled. These calling charts, had all the MOSS family of software categorized by function, program(s) used and routine calling sequence.

Specific task development was then guided by the calling charts put together. The basic strategy was to first have the "frame" of each subsystem installed and running on the PRIME install directory. Incrementally, the "frame" would be delivered with new functionality. The increment was guided by three criteria:

a) Communication and data transfer needs. The CAPTURE function of ADS, the IMPORT function of MAPS and the IMPORT function

of MOSS were the first installed.

b) Logical/Lexicagraphical order. Since there was no clear "system" division in MOSS in general, conversion proceeded following the calling chart handbook on a program basis.

c) The above two criteria would be overwritten if system documentation was hindering the conversion process.

All the issues of mapping CLI functions into CPL had to be accomplished prior to any further software modifications. These included:

a) PUSH/POP
b) Environments (DIRECTORY, SEARCH_LISTS)
c) Linkages. Linkage resolving.
d) List searching

The CLI conversion was to proceed on a top-down/bottom-up fashion following the frame schema whenever possible.

3.- The software strikes back

Once having completed the software conversion and passed the governments quality assurance tests, several important facts about the MOSS family of programs have come to light. They will be useful in handling the potential problems that will come up with it's use under FORTRAN 77.

It goes without saying that there is a profound dimension to the design of software systems. Designing not only affects the overall architecture, maintenance and efficiency of a software system, but it also greatly affects it's reliability. There are several aspects in the designing of a software system that one has to cover: functional design, architectural integrity design and efficiency design. These three types of design are mutually exclusive in many ways and one has to carefully blend the three to allow the design goals of functionality, integrity and efficiency to meet.

Designing for architectural integrity and efficiency requires a concentration on the important aspects of the problem, so as to avoid redundant computations and to design data structures that exactly represent the information needed to solve the problem. If the design is successful, the result is not only an efficient, reliable and architecturally sound system, but a collection of tools and methods that will allow the graceful expansion growth of the system.

Geographic information systems are technologically complex systems. It has not been until recently that software engineering design techniques have been applied to the design and implementation of GIS. United with the advent of computational geometry, computational topology, modular/structured programming, and compiler enforced ANSI standards,

the development of GIS software becomes more robust when it follows the proper engineering guidelines.

3.1.- Conversion Issues

There are several issues that come up when converting an old software system like the MOSS family of programs. The MOSS family of programs may have had a initial functional design. However, there is no evidence that it went thorugh a design cycle where integrity and efficiency were considered. There is a strong indication that the system grew with no design guidelines. By not having these guidelines the system,having been developed by persons with different backgrounds, expanded in a very haphazard way.

The initial implementation of MOSS in general goes back as early as 1977. This makes the system a technology 10 years old that never caught up with present methods and techniques. Ten years in the computer field has brought us the S130 Eclipse in the size of a hand held calculator.

The hardware architecture and software system support on which the MOSS system "grew" allowed for many violations of architectural integrity of which the user would never be notified. Aside from checking file status I/O, one can say that there is almost no formal assertions imbedded in the code about it's behaviour. The developers of the code in general did not consider how the algorithms could fail.

The result of migrating MOSS to a newer hardware environment with enforced ANSI standards and operating systems on the look out for "memory corruptors" or "violators of restricted areas" is that we have been able to shed light on future potential problems that may come up and will need to be addressed.

In the MOSS software conversion we can differentiate the phase of converting the software so it executes like it did on the old hardware/software architecture environment and the phase that "corrects" violations that appear in the new hardware/software architecture environment. The "corrections" were not to make the algorithms any better but were to emulate the behaviour of the software from the old architecture to the new architecture. Despite that the process has left the algorithms in the same state, it has been useful to identify the reasons behind it's erratic behaviour. This has opened a previously undisclosed matter by those who maintained the family of programs. The following cases illustrate some of the problems.

Case 1

Processes like BUFFER and OVERLAY which "sometimes work" and other times produce unuseable results is caused by the divide by zero. The following test executed on an MV4000 with AOS/VS and FORTRAN 5 ignores divide by zero:

```
**** AOS/VS Rev 7.54.00.00 / Batch Output File ****

AOS/VS CLI    Rev 07.54.00.00  18-MAR-87  12:32:43
) SEARCHLIST :MACROS,:UTIL,:LANG:TCS
) DIRECTORY :UDD: ABDHUL:TEST
) DEFACL  ABDHUL,OWARE,+,RE
)
)
) TYPE DZ.FR
C
C .. Program to test divide by zero condition
C
      IANS = 3 / 0
      TYPE "IANS=",IANS
      END

) X DZ
IANS=        3

)
End of file
AOS/VS CLI   Terminating 18-MAR-8712:32:45
```

The same test executed under FORTRAN 77 on the DG was not acceptable and the program halted with the message "Fixed point overflow... ERROR 71174".

This problem is algorithmic in nature. The piece of code that has a potential divide by zero should have a formal assertion of the kind:

```
C
C .. Check that denominator is not zero. If it is, do not
C    continue. State is non-valid
C
      IF (DX.LT.SMALL_DX) THEN
       MSG = 'Invalid DX result. Unable to continue (CHK_DX).'
       CALL FATAL (MSG)
      ELSE
       HALF_X = XX / DX
      ENDIF
```

Under FORTRAN 77, to allow for the code to execute like it did under DG FORTRAN 5, if the denominator is zero, then the results are set to the numerator. This is:

```
IF (DX.LT.SMALL_DX) THEN
 HALF_X = XX
ELSE
 HALF_X = XX / DX
ENDIF
```

The above will yield the same results as those of the old DG FORTRAN 5, however, the results are incorrect !. The conversion team has flagged this type of error wherever found.

Case 2

Fixed point overflow:

```
AOS/VS CLI    Rev 07.54.00.00    27-MAR-87    14:13:29
) SEARCHLIST :MACROS,:UTIL,:LANG:TCS
) DIRECTORY :UDD:?ABDUL
) DEFACL ?ABDUL,OWARE,+,RE
)
) TYPE TST.FR
      REAL RVAL
      INTEGER IBUFF
      RVAL = 654399
      IBUFF=RVAL
      TYPE IBUFF
      END

)
) X TST
   31807

)
)
End of file
AOS/VS CLI   Terminating   27-MAR-87   14:13:30
```

In the above example a floating point number (32 bits) has been assigned to an integer short (16 bits). The code did not halt warning of the failure. In F77 this code would cause an overflow message. In the case of MOSS this type of operation has been found in several places, take for example the following lines from the routine ADCORD:

```
SUBROUTINE ADCORD(IARR,NVERT,NREC,XXMIN,YYMIN,ICHAN,SCALE,IZZ)
COMMON /DEBUG/ IDEB
COMMON /IO/ NPRNT,IOIN
COMMON /CSTFC/  IZ,IPOINT,SC,XMIN,YMIN
DIMENSION IBUFF(128)
DIMENSION IARR(128),IR3(2)
EQUIVALENCE (SC,IR3(1))
                     :::
                     :::
```

```
                            :::
C  ENTER TRANSFER LOOP
C
          DO 20 IPOINT=1,NVERT
C
            KOUNT=KOUNT+1
C
            XT=((X(IPOINT)-XMIN)/SC)
            YT=((Y(IPOINT)-YMIN)/SC)
            IF(IZ.EQ.1) ZT=YR(IPOINT)
            XT=ANINT(XT)
            YT=ANINT(YT)
            IF(IDEB.NE.0) WRITE(IOTABL(NPRNT),2002) XT,YT
 2002       FORMAT(1X,2F10.2)
C
            IC=IC+1
            IBUFF(IC)=XT
            IC=IC+1
            IBUFF(IC)=YT
C
               :::
               :::
C
          RETURN
          END
```

Note that IBUFF is defaulting to INTEGER*2. If SC is not set correctly XT and YT would overflow IBUFF. In the case of FORTRAN5 it is truncating to the rightmost 16 bits without notifying the user of the problem. In the case of F77 it just halts with a fatal system error message.

Case 3

In some instances the conversion discovered cases where memory overwrites are not detected under FORTRAN 5. The following simple case that uses RDLIN from ADS is trashing memory by not having arrays dimensioned properly:

```
AOS CLI   REV 07.01     9-APR-87      15:39:21
) SEARCHLIST :UDD:BLMOP:CLIS,:UTIL,:,:COMPILERS:FORTRAN5
) DEFACL WENDY,OWARE
) DOIT
        DIMENSION IANS(1),JUNK(2)
        DATA IANS /2H  /
        DATA JUNK/2H  ,2H  /
        OPEN 11,"@INPUT",ATT="SIB"
        OPEN 10,"@OUTPUT",ATT="SOB"
        CALL RDLIN  (11,IANS,ICNT,IER)
        WRITE (10,9) IANS,JUNK,ICNT
9       FORMAT ("NAME=",1A2," JUNK=",2A2,I5)
        CALL EXIT
```

```
        END


YES
NAME=YE JUNK=S
      4

)
)
END OF FILE
AOS CLI   TERMINATING    9-APR-87     15:39:27
```

In the above case, if the user answers "YES" to a prompt where at the top level there is only room for "YE", a memory overwrite is caused. If the user answers "Y" all is tidy. Under F77 this memory overwrite can cause a pointer fault or damage a subroutine transfer call.

3.2.- Errors revealed by FORTRAN 77 and PRIMOS

If and when a part of the MOSS software is to fail with a system error message like:

- File in use
- Unit not open
- Stack overflow
- Pointer fault
- Illegal segment number
- File already exists
- Float to integer overflow

or if the "procedure "hangs" the things that may be causing the problem are the following:

a) Documentation on file structures does not agrees in several instances with the actual implementation. For example, DESCRIBE.FA is used as 16 words long in some cases, in others it is used as 128 words. This would work fine on the DG which allows mixture of file types and I/O handling modes. It does not work on the PRIME where more strict rules about file handling are enforced (e.g. mixing of RDSEQ with WRITE BINARY, WRBLK with simple FORTRAN READ, etc.)

b) Routines calling other routines with wrong number of parameters creating a pointer fault.

c) Arrays being declared as two dimensional and then handled as one dimensional throughtout the code, creating a memory overwrite codition.

d) Routines calling routines with constants and then the "called" routine overwriting the constant upon return creating an access violation.

e) Arrays indexed out of bounds creating a frame stack-crawl out, or

causing the process to "hang".

f) Mixing of file types. Sequential with direct access. Opening a file read only and then writing to it. Improper handling of channel numbers. Leaving channels open when exiting process.

g) Code redundancy. There are multiple copies of the same routine throughout the system violating the integrity of the software data base. Routines with the same name and function, varying in number of parameters.

h) Violation of the concepts of information hiding and module implemented in packages like TCS by accessing and altering the contents of the common blocks. This makes difficult to debug the code.

i) Uninitialized variables, e.g. counters. On the DG FORTRAN5 these are defaulted to zero. In F77 the value is undefined or just "garbage". This can cause an array out of bounds condition or a process taking the wrong branch.

j) On the DG ASCII data has the standard high bit OFF. On the PRIME the high bit is ON. The MOSS code has "hard-wired" ASCII constants in many places for parsing or checking for certain conditions. Since in FORTRAN5 the CHARACTER data type did not exist, character strings are handled via integer arrays and hollerith expressions. In this sense an evaluation for blank like this:

```
IBLANK = ' '
       :::
       :::
IF (IBLANK .EQ. 32) GOTO 10
       :::
```

has to be converted to

```
IF (IBLANK .EQ. 160) GOTO 10
```

This point of the high bit ON vs. high bit OFF is a very important one and has been probably the most cumbersome to overcome in the conversion process.

k) Do loops in the code have caused the software to hang. For example

```
  IF (IANSWER.NE.'Y') GOTO 20
              :::
              :::
  DO 20 K=1,N
      :::
      :::
20 CONTINUE
```

At the point of the 20 CONTINUE entry, K is undefined. In F77 this will cause an "infinite" loop (this is known as "jumping into the range

of a DO loop"). Another example that can cause a different problem and related to the DO is the following:

```
          DO 20 K=1,0
             :::
             :::
       20 CONTINUE
```

Under FORTRAN5 this loop will be executed once. It will never be executed under F77. Results are unexpected.

The award winning blunder in the code was found in an AMS routine. An extract of the code is the following (see if you can detect problem):

```
      SUBROUTINE EMUL (IFLAG)
              :::
              :::
              :::
C             IF (.NOT.VALID) WRITE (LU1,7004) II,IBCODE
7004          FORMAT ('  CHARACTER ',I2,' IS BAD = ',1I3)
              IF (.NOT.VALID) GOTO 56
51          CONTINUE
56        CONTINUE
          IF (VALID) GOTO 52
C           THEN - this is not a valid input string from table
            WRITE (LU1,5001)
 5001       FORMAT (' MEASUREMENT NOT ACCEPTED - TRY AGAIN !')
 53         CONTINUE
            IF (1 .EQ. 0) GOTO 58
C             THEN - bell is turned on
              DO 57 I=1, 2
                CALL WRSEQ (LU1,BELL,2,IEE)
 57           CONTINUE
 58         CONTINUE
            CALL SITE (LU1,9999,CDATA,IRR,IER)
 52       CONTINUE
                 :::
                 :::
                 :::
C
9000  RETURN
      END
```

If you were unable to find the "bad" instruction here it is:

```
            IF (1 .EQ. 0) GOTO 58
```

as you can see, there is something wrong about it !.

The above examples are but a few of the many encountered during the conversion. It, however, is a comprehensive set of samples that give an accurate description of the code problems present in the software

data base.

4.- What next

On April 10, 1987, 5995 man/hours later (almost 3 man/years), the MOSS conversion project had successfully met it's delivery date and passed all the government's quality assurance tests.

During the delivery of the software on the week of April 6, I had the opportunity to meet with the government's technical group for the future maintenance of the software. I personally think that this software has no future unless it is re-written. Here are several observations:

a) User Interface The user interface is not consistent throughout the code. There are multiple parsers. In some instances you answer "Y" or "N"; in others "YES" or "NO"; while in others (1=YES / 0=NO). Error recovery is poor or non-existent. Some menus force you to answer "something" before you can exit. Although the feature of mixing a command driven parser with a prompt driven parser is a good one, it loses it's value in poor implementantion. In technological terms, the user interface is obsolete; menu design and implementation is not present. To obtain such a capability, a new user interface has to be written. I think one of my biggest fits with the code was when we finally were able to export some maps from the DG to the PRIME. The MOSS IMPORT program finished then and asked if I wanted to delete the input map. I said no (in lower case). It defaulted to delete the map !.

b) Data structures and data models Because there are no definition or implementation of concepts of tight coding, encapsulation, module and information hiding it is difficult to talk about data structures. In any case, the adopted file definitions are very heterogeneous across system programs. In general MOSS provides the user with a rudimentary flat file structure and a redundant polygon vs. ARC data representation method. One can not precisely conceptualize a given data model used. The redundancy used in the system will cause the data base to corrupt.

c) Algorithms Functionally speaking the MOSS family of programs ressembles a GIS. The algorithmic redundancy in the code is rather fascinating, e.g. several point-in-polygon routines, several ways of doing overlay, various methods for digitizing, contouring, rasterizing, etc.. It is unfortunate however to find that not one method is reliable. This algorithmic excess can only but create confusion from the maintenance point of view. For the user it is a total nightmare: should I use OVERLAY, GOVERLAY, BLMOVER or PLOVER ?!.

5.- Conclusions and recommendations

The MOSS conversion project was succesful in migrating the family of software from the DG and FORTRAN 5, to the PRIME and FORTRAN 77. In the process it revealed the conditions in which the code was functioning. One can say that the software now will be less flaky and pronounce itself by halting with a hard error. In many instances, the Data General under FORTRAN 5 would not halt a program had a major error occurred internally.

The EROS Data Center Report on "An Evaluation of Vector Based Geographic Information Systems At The Eros Data Center" (David Greenlee, Jan Van Roessel and Michael Wehde, 1986) has some implicit results that are to be seriously considered about MOSS. One can conclude from this report that one of the main problems of MOSS et.al. is it's lack of robustness. Who cares how flashy or easy to use a system is if it does not work !.

A 1984 EDC study ("A Study of MOSS and IDIMS: The FMLIS Pilot Project Example) concluded that MOSS's most serious problem were related to spatial recategorization and overlay functions.

"The Feasibility and Design Study for the Enhancement of MOSS" produced by Autometrics in 1984 for the USGS is an accurate assesstment of the changes the software has to go through. It is worthwhile noting however, that before any enhancements can occur, the current state of the software can only but get in the way of changes. The software has to be modularized to make maintainability efficient; the algorithms need to be revised/re-written to be made reliable; the data structures need to be changed from polygon based to ARC/NODE; realistic attribute handling has to be added; DBMS facilities have to be incorporated with the ability for spatial searching, and on and on.

Designing and implementing a software system is a neverending task. Our experience with the software life cycle shows careful design to be critical because this initial stage will always be re-visited: all software architectures have a curve of diminishing returns. As the structure grows it can interfere with system efficiency. When this happens, it is time to expand the design criterion and re-configure/modify the present architecture. In the case of MOSS, this is quite difficult since there are no clear architectural design concepts.

In the initial design phase of a system, maintainability is a main issue. In our experience, most maintenance is caused by changing requirements rather than by reliability problems (this is true with a robust system). Maintenance is key to the software life cycle since it involves:

- Error and design defect correction

- Design improvement

- Software performace improvement

- Software conversion to different hardware platform, use state-of-the-art hardware features, telecommunications facilities, station configurations, etc.

- Software interface to other systems

- Data base architecture changes

- Application changes or enhancements.

From the experience of the conversion, my conclusion is that MOSS has served it's time and is ready to be retired. If this approach is not taken, the effort spent in "fixing it" will go beyond any time scheduled and allocated budget. In the long run, it will be better to license a well known and reliable GIS product.

To conclude, I think the key issue that comes up is whether or not the government wants to be in the GIS software research and development business, allocate the time, funds, and commitment to the enterprise, and support the user community with the appropriate system maintenance, documentation and upgrades.

6.- Aknowledgements

The MOSS conversion project was a success thanks to the major efforts made by Scott Morehouse (ESRI), Mark Oliver (ESRI), Peter Aronson (ESRI), Keith Ryden (ESRI), Lauren Kyle (ESRI), Andy Norton (ESRI), Donna Annis (Martel), Mark Meiser (Martel), Chuck Smith (PRIME) and Mike Cleaves (PRIME). The government technical assistance headed by Charles Gish, Mike Carsella, Doug Sipes and Wendy Tedley were greatly appreciated.

MOSS Systems Session

Section 3

AUTOMATED PERMIT ANALYSIS SYSTEM

BY

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••••• INTRODUCTION •••••

The Coastal Management Division (CMD) of the Louisiana Department of Natural Resources is legally mandated to control permitting of certain activities in the Louisiana Coastal Zone. The Coastal Zone is approximately the five foot contour in southern Louisiana and comprises about 5 million acres. The regulation is designed to balance both the economic use of the area as well as its environmental health. The mechanism used for this regulation is permitting. Approximately 1500 permit applications are received each year. Analysis of permits requires knowledge of the environmental and cultural conditions of the affected area. This information exists on a combination of about 4000 maps, charts, Landsat scenes and aerial photographs which are used by CMD analysts. CMD has a Data General MV/10000 computer with AMS, MOSS, ERDAS and FORTRAN software systems on which a large portion of the maps have been computerized and are available to MOSS.

This paper describes the automated system that was developed by Decision Associates, Inc. for CMD under a grant from the NOAA Office of Oceans and Coastal Resource Management. The system consists of a set of linked programs that automatically performs an analysis of a site for permit review evaluation. This paper is divided into 5 parts related to the automation of permit analysis:

1. MOSS Automatic Permit Analysis System -- an overview;
2. Map Index Program (MIP);
3. MOSS Command Interpreter (MCI);
4. Remote execution of the MOSS system using a Macintosh™;
5. A Decision Tree for Coastal Use Guideline Analysis.

••••• OVERVIEW OF AUTOMATIC PERMIT ANALYSIS •••••

Permit analysis requires GIS functions such as:

A. Identification of the maps on which the permit site occurs;
B. Proximity searches in the vicinity of the site;
C. Location of sensitive and prohibited areas relative to the site;
D. Location of other permitting activities in the area;
E. Habitat change detection and acreage calculations;
F. Statistical analysis;
G. Printed output of geographic data and analyses;
H. Graphical hardcopy of the maps and special areas of interest.

We have automated portions of the CMD permitting process. This was accomplished by the use of many computer system MACROS, a Map-Indexing Program (MIP) and a MOSS Command Interface (MCI). The output of this process is discussed below, but we feel that an overview is in order. The permit's geographic location is given to the Map-Index Program along with two pieces of identifying information. The MIP geographically locates the study area and determines the computer maps that are appropriate. After doing its own analysis, this information is then passed to the MOSS Command Interface (MCI) which creates a command file for MOSS and automatically executes MOSS using this command file. No direct user interaction with MOSS is required. By using this process, approximately 95% of the questions that MOSS would normally ask are not posed for the user. The user is, therefore, not required to know the names or syntax of the MOSS commands nor the order in which they must be executed to accomplish the desired analysis. Thus, routine MOSS analyses can be run by a technician, thereby freeing the permit analyst for evaluation of results and other tasks.

As an example, to obtain A through H above for a radial proximity search, about 35 computer commands and 90 MOSS commands would be required. These MOSS commands require over 200 responses for arguments. Using the Map-Index Program/MOSS Command Interface (MIP/MCI) system, only 4 of the over 300 responses are required of the user. Furthermore, the questions asked to obtain this information are stated in familiar terms thus avoiding confusion and mistakes.

The above discussion pertains to an AUTOMATED analysis which is run on a daily basis. In addition, other types of analyses can be performed using the MIP and MCI and are discussed below. These analyses would be useful in special cases where linear features, polygonal study areas, economic or special areas are encountered.

The MIP can be used on a routine basis to aid CMD personnel in identifying and/or locating geographic information. It is also an aid to the many outside people who use the resources of the office. Besides identifying relevant maps, the MIP also prints a list of navigation charts, photographs and LANDSAT data sources on file of a specific site.

DESCRIPTION OF AUTOMATIC MOSS ANALYSIS OUTPUT

The following section is included to provide an example of analysis products routinely produced by the Automatic Permit Analysis System. The reader is referred to the example output following the paper. This is the actual output with the exception for the compression used to reduce the number of pages. The map index allows the identification of any permit site on the appropriate map in the data base with the input of a latitude/longitude location. Any map type occurring in that location can be identified and automatically retrieved using a standard map area index moniker. The analysis is then accomplished by performing a proximity radius search of variable size on the data in question. Comparisons are made of two years to produce change statistics for environmental habitats. Also, sensitive environmental areas in the radius are flagged, and other permit locations in the proximity are identified and reported from a multiattribute file. Area tables and change table statistics are produced and hardcopy vicinity maps and proximity maps are generated - all automatically.

A set of output from the Automatic Permit Analysis System is included at the end of this paper. This set has been pared down by removing some sets of similar analyses and maps have been reduced and combined on pages to conserve space. A copy of the actual output is available from the authors. The sample output of consists of:

A. A title page with the original input plus other data determined by the MIP;

MIP

B. A title line for the MIP output;
C. Reiteration of the input parameters;
D. The UTM coordinates of the study area;
E. Up to six sets of information detailing the the appropriate maps including;
    1. The description of the map series currently being reported on;
    2. The map number designation given the particular map by CMD;
    3. The USGS map name;
    4. The moniker or prefix used to name the computer file containing the map;
    5. The map ratio and interval scales;
    6. The three closest adjacent maps (all eight are obtainable as an option);
    7. The ground distance from the permit location to the edge of the map;
    8. The map distance from the permit location to the edge of the paper map;
    9. A list of all hardcopy maps that CMD actually has in house.
F. All Landsat TM scenes which include the permit location along with;
    1. The approximate center of the Landsat scene;
    2. The scene quadrant in which the permit site is located;
    3. The name, date and CMD number of the scene;
    4. The scene ID;
    5. The magnetic tape number where the scene is stored.

G. Five sets of information pertaining to photographs likely to be of the most use;
    1. The series name of the photographs;
    2. The maximum search radius for photo centers;
    3. The approximate scale and the interval scales of the photographs;
    4. The nine photos whose centers are closest to the permit sorted by distance.

H. The file names of all computer readable maps on the system.

MCI

J. A MOSS AREA summary of the proximity circle (p.c.) for the 1956 data;
K. A MOSS AREA summary of the p.c. for the 1978 data;
L. A report on the changes occurring between the 1956 and 1978 data;
M. A report on any linear features found within the p.c.;
N. A report of any polygonal environmental sensitive features within the p.c.;
O. A multiattribute report on all previously requested permits within the p.c.;
P. A MOSS AUDIT of the 1956 habitat polygons;
Q. A MOSS AUDIT of the 1978 habitat polygons;
R. A PLOT of the appropriate 1978 7.5 min quad with the p.c. superimposed;
S. A PLOT of the 1956 p.c. with the habitat polygons labeled;
T. A PLOT of the 1978 p.c. with the habitat polygons labeled;
U. A PLOT of the p.c. with previously requested permits numbered;
V. A SHADEd PLOT of the 1978 p.c. coded for habitat type.

Other inventory information is generated as well, and new data variables are continually being added. Improvements developed but not yet added to the automated analysis include a routine that allows the automatic and very rapid shading of a map. This same routine will also aggregate subjects, thus enabling habitat categories to be generalized when needed. Also ready for inclusion in the automated generation is a proximity analysis obtained from the classified Landsat TM data of the Louisiana Coastal Zone which was recently completed by Decision Associates.

In summary, the procedure described above requires only the latitude, longitude location and two identifying items. It then runs unattended to produce the output products attached. No direct interaction is required. In actuality, we have taken the process one step further in that we allow the user to batch any number of requests and have the whole series run to completion. One analysis takes from 15 to 25 minutes and CMD runs an average of six per day. This number is down from its previous levels due to the decrease in oil exploration.

••••• MAP INDEX PROGRAM •••••

As mentioned earlier, permit analysis requires reference to a large amount of geographic data to assess environmental and cultural conditions. For this reason, CMD houses an extensive collection of geographic reference materials. Because of the large size of the collection, there was a need to create a database to improve access. The maps were geographically cataloged and organized for cross-indexing via computerized search, retrieval and report generation. The user has only to specify the geographic coordinates of a location and the system will present a summary of all relevant materials. Output from this program is a list of all hardcopy and computerized maps, charts, Landsat data and photographs of the study area along with information used to physically locate the permit position on hardcopy maps. Also printed is a list of all the names of the computer maps available of the study area. This output has been described in more detail earlier.

The MIP is used on a routine basis to aid the CMD personnel in identifying and/or locating geographic information without initiating an automated analysis. It is also an aid to the many outside people who use the resources of the office.

MAPS

The database consists of two types of information. The first -- the AREA FILE -- is a set of all USGS map formats which cover the Louisiana Coastal Zone. Information for each quadrangle includes the minimum bounding rectangle, adjacent map pointers, CMD reference number, scale and name. Note that these data are generic -- they contain no references to actual hardcopy products. The second part of the database -- the MAP FILE -- contains one record for each existing hardcopy map product actually in CMD's possession. These records contain the map type, date and storage location and are linked to the AREA FILE by the CMD reference number. When the user specifies a geographic coordinate, the MIP locates the generic area using the MBR's in the AREA file, obtains the CMD reference, and reports on all products in the MAP file with this number.

The AREA file includes the following map formats :

1 / 24,000 QUAD SCENE = 7.5 MINUTE QUAD
1 / 63,500 FULL SCENE = 15 MINUTE QUAD
1 / 80,000
1 / 100,000
1 / 250,000

The MAP file includes the following map types that exist at CMD:

◊ Topographic
◊ 1956 Habitats
◊ 1978 Habitats
◊ Oyster
◊ Socio-economic
◊ Mineral
◊ Soil & geomorphology
◊ Climate & hydrology
◊ Active processes
◊ Biological

AERIAL PHOTOGRAPHS

Because no standard area scheme exists for aerial photographs, it was not possible to construct an AREA file for them and they were handled differently. For each photo in-house, a record was created containing its geographic center point, format, scale, storage location, series, date, roll, frame and CMD numbers. Because it is difficult to georeference photos, only the center is in the index. When searching for photos that might be relevant to the site under investigation, the scale is used in conjunction with the center to establish a search radius that is equivalent in miles to 1.5 times the diagonal of the photograph. Within this search radius, the nine nearest photos are identified and reported in order of increasing distance from the site.

The series that currently exist at CMD are:

NASA74 EPA74 NASA78 NHAB NASA85

LANDSAT TM DATA

A situation similar to the aerial photos exists with the Landsat TM data in that no exact area scheme exists. For this data, the scene corner-point coordinates were stored. This allowed the MIP to place the site in the proper Landsat scene(s). Data for each scene includes the scene id, path, row, date, format, storage location and magnetic tape number on which the scene is stored.

••••• MOSS COMMAND INTERFACE •••••

The permit analysis process requires certain time-consuming and repetitive functions that can be performed by a computerized system such as MOSS. Automation of these functions would result in speeding up the permit process and thereby allow the analyst additional time to apply his expertise in more important areas. Furthermore, the computer operations required to accomplish these tasks can be automated to the extent that very little input is required to accomplish a series of analysis procedures.

The permit analysis procedures used by the CMD analysts were documented from the Coastal Use Permit Review Sheet, and the tasks that required reference to maps or location data were identified. Although many permit analysis functions are possible to do on the computer, several are obvious and of much value to the reviewer. These include but are not limited to:

◊ Plotting a map for visual inspection, query and measurement;
◊ Performing a radius proximity search for habitat types, ecological, sensitive areas, other permit sites, endangered species, archaeological sites, etc.;
◊ Comparison of two dates in the same region for change detection;
◊ Statistical analysis and acreage calculations;
◊ Identification of maps on which a site is located.

MOSS command sequences were developed to accomplish the specific functions of the permit review process that required references to computerized habitat maps, sensitive area maps and existing permit applications. Menu items were devised to reflect the information requirements for permit analysis such as the types and acreage of ecological habitats in the area, the location of ecological sensitive areas in the vicinity of the site, the change that has taken place from 1956 to 1978 in habitats, and the location and type of other permits within the region. Many more such customized procedures can be added to the menu list. Current menu selections generate hard copy output maps of the search radius, statistical tables of areal information, and reports on multiattribute file contents.

MOSS incorporates a powerful Geographic Information System (GIS), however, the ability to use this software is dependent upon the user being familiar with a number of concepts. For the unfamiliar, using MOSS can be likened to flying a jet plane where the controls are labeled in a foreign language. The MOSS user is normally required to understand not only his problem, but also the commands that are necessary along with their sometimes obscure arguments and the complicated sequences that are often necessary. For these reasons it was decided to construct a user interface to MOSS.

There were many objectives in the development of this interface. These were primarily aimed at simplifying and speeding-up MOSS analysis while providing the ability to run repetitive, routine jobs with the use of technicians. It was important to modify MOSS program code as little as possible. These objectives also included the following:

◊ Automatic production of hard copy products;
◊ Handling the problem of adjacent maps;
◊ That little or no knowledge of MOSS be required;
◊ The MOSS analysis be transparent to the user;
◊ The system be user-friendly and fault tolerant;
◊ The ability to have helpful messages;
◊ The ability to rerun a series of steps with little work;
◊ To converse with the user in familiar terms & English;
◊ The full use of MOSS capability;
◊ The ability to run routine analyses unattended -- a corollary to this is that all input is entered immediately upon execution so that an analysis that may require commands every hour does not require a attendant.

The first section of this paper pertains to an AUTOMATED PERMIT ANALYSIS which is run on a daily basis. In addition, other types of analyses can be performed using the MCI. These analyses are useful in special cases where linear features, economic or special areas are encountered. The MCI can be used to investigate unusual or special situations as well as for those permits of a sensitive nature where a more detailed evaluation is required. The user of the MCI is presented with a menu of choices from which it is only necessary for her to select the appropriate analysis type. The MCI then requests the minimal required information. Those questions asked by the MCI are tailored to the user in an English sentence style. Approximately 90% of the questions are eliminated and no detailed knowledge of MOSS is required. Additional MCI commands can be added by someone knowledgeable in MOSS with no programming required.

The Data General computer operating system, AOS/VS, allows the user to create a set of commands followed by their input and store this sequence of lines on disk. Execution is begun by using a /M "switch" on the execute command. It is therefore possible to create a disk file with all the desired commands and input and cause them to be executed by simply typing the name of the disk file. The method used was to write a FORTRAN program that presented the user a menu, asked a few English-type questions and then created a disk file with all the dialogue required to perform the task desired. This procedure relieves the user of the burden of being familiar with MOSS commands, command sequences, syntax and nomenclature. It also eliminates the need for him to invent and maintain numerous temporary disk files. The interface program also allows for the introduction of simple English syntax questions when the user must be asked for information. The program to interface with MOSS has been termed the MOSS Command Interface (MCI).

The MCI uses the following technique:

1. The user logs on and the MCI program is automatically invoked;
2. A menu of choices is read from disk and presented;
3. The user chooses an entry by number;
4. The MCI reads and interprets directives given in a skeleton command file named TYPEnn.CMD where nn is the menu choice selected;
5. The user is queried for required data;
6. The MCI makes the appropriate substitutions in the skeleton command;
7. The MCI then creates a file named MCI.CMD.CLI and writes into it all the commands and dialogue required to run MOSS;
8. This file is then executed whereby the analysis is performed.

It was necessary to make one change in MOSS however. When plotting, the MOSS PLOT routine uses multi-tasking to monitor the keyboard to allow the user to abort the plot job. More specifically, MOSS monitors the input device -- usually the keyboard -- looking for an abort command. In our case, however, the input device was a disk file. It was necessary to defeat this "looking" to prevent MOSS from reading and discarding all the rest of the data in the disk file that is used as input in our case.

Initially, attempts were made to invoke command sequences via the MOSS BUTTON command. After extensive attempts at doing this, it was decided that the `BUTTON' approach would not be feasible because of two major factors. The first was due to the fact that MOSS command sequences within the BUTTON formats were limited to 80 characters. This is far short of what was needed. Secondly, MOSS commands generate a large number of prompted responses, many of which do not have obvious or easily understood arguments. Consequently, this led to a decision to abandon use of the BUTTON commands in favor of the above approach that provided an interface between the user and MOSS with a menu format.

••••• MOSS EXECUTION VIA A MACINTOSH •••••

We have recently setup a remote MOSS workstation using a Macintosh as the remote terminal. This setup was employed to run the Automated Permit Analysis System. The cost of this machine was about $3,000 for both hardware and software. The software used was a terminal emulation program named VersaTerm Pro™ written by Lonnie Abelbeck. Besides being a superb terminal program full of features, VersaTerm Pro has the ability to emulate four different terminals. These are the DEC VT100, Data General D200, Tektronix 4014 and the Tektronix 4105 -- a combination of unique utility to the MOSS community. This particular combination of features is such an attractive way to work that we have on occasion used the Mac locally for documentation purposes -- this paper for example. The Mac/VersaTerm runs at 9600 baud very nicely.

Using the Mac as a terminal offers some outstanding benefits. The maps can be saved on disk and then manipulated and included in a database or textual report with the proper software. Additional advantages include:

- ◊ Inexpensive as it replaces both text and graphic terminals;
- ◊ Even less expensive if you already have a Mac -- VersaTerm Pro costs $295;
- ◊ Takes less room for the same reason;
- ◊ Can do local processing;
- ◊ Can get LaserWriter output;
- ◊ Can print color maps using Imagewriter II and a color printing program;
- ◊ Can customize maps by pattern filling, scaling, etc.;
- ◊ Can emulate a color Tektronix if user gets a Macintosh 2.

While this project is still in its startup phase and some minor problems still remain to be resolved, we are extremely high on the Mac and VersaTerm combination. If you don't already have a Mac you should run right out and get at least one.

••••• ISM DECISION TREE •••••

The process of permit review obviously includes more than a geographic analysis of the permit area as performed by the automated routine. Each permit application must be evaluated with regard to a set of guidelines related to environmental considerations. These guidelines are grouped according to feature, and one or more groups must be considered for each permit. There are approximately twelve guidelines per group.

Review of the guidelines can be tedious, and an opportunity to make this process more efficient and uniform was explored. The primary goal was to assess the guidelines with regard to their relationship with one another based on the possibility that compliance with a specific guideline would automatically satisfy compliance with one or more other guidelines. This relationship among the guidelines allows a decision tree to be constructed such that a review of the guidelines in a structured order would reduce the necessity of reviewing all the guidelines since some are in the domain of others.

With a team from CMD, a computer technique termed Interpretive Structural Modeling (ISM) was used to develop a guideline decision tree for the various sets. ISM is a group decision making process which allows the group to define the pattern of relation among a set of elements and express this pattern in a hierarchical graph format. This is accomplished with a series of comparisons and the use of inference which reduces the number of actual comparisons needed to define the structure. The resultant trees were translated to tables and saved in computer files. A program was written to follow the

tables and present the guidelines for review to the analysts based on their response to the permit's compliance.

There are plans to ultimately link the Decision Tree to the APAS. When a guideline calls for reference to map or environmental data, this request could be passed to the APAS where the analysis could be performed automatically and the results presented to the analyst.

Quantification via the decision tree can be taken a step further. Since the importance of each guideline is known, they can be weighted and the reviewer will be able to respond with the level of compliance of the permit to each guideline based on a scale (0-4). Scores will then be derived for each permit based on the guideline weights and on the permit's overall degree of compliance with all guidelines. This will provide the analyst with additional means to quantify permit evaluation.

This program provides several additional benefits including:

◊ A standard and consistent methodology for reviewing permits;
◊ An efficient method of determining the relevant guidelines;
◊ A printed copy of the guidelines which apply;
◊ Speeding up of the analysis.

An aspect common to many of the above procedures is the printing of hardcopy output. This information can be very effectively used in several ways:

◊ Included in the permit file for documentation;
◊ A convenient source of information for further investigation;
◊ Sent to the user along with the usual CMD response.

We feel that the value of the last use is an often overlooked benefit of these types of programs in that the computer output:

◊ Helps to make the requestor aware of the thought and work that went into making permit decisions;
◊ Helps to make the requestor aware of the amount of work that was devoted to THEIR permit;
◊ Helps to quantify rather than just qualify the analysis to the requestor;
◊ Sometimes emphasizes the importance of the information presented more than typed material.

DECISION ASOCIATES,INC. ◊◊ MAP INDEX PROGRAM OUTPUT

DECISION ASSOCIATES, INC. MAP INDEX SYSTEM FOR CMD 09-09-86 run 9-19-86 16:02:16

STREIFFER permit P860530 lat 29-24-50 (29.4139) long 90-12-39 (90.2108)
UTM ZONE: 15 NORTHING: 3256901.47 EASTING: 770636.46

7.5 MIN QUAD: 243A NAME: GOLDEN MEADOW FARMS MONIKER: GLDMF
SCALE 1: 24000 INTERVAL: 1" = 2000.0ft, 609.6m, .610km

ADJACENT MAPS:	GROUND DISTANCE TO BOUNDARY	MAP DISTANCE TO BOUNDARY
244B WEST	2.35mi = 3.77km	6.19in = 157.3mm
244D SOUTHWEST	3.56mi = 5.73km	9.40in = 238.7mm
243C SOUTH	2.68mi = 4.31km	7.07in = 179.6mm

SOURCE	CMD #	NAME	MONTH	YEAR	P.R.
H/C MAP :	243A	TOPOGRAPHIC		1956	1979
H/C MAP :	243A	1956 N.W.I. HABITAT MAP		1956	
H/C MAP :	243A	1978 N.W.I. HABITAT MAP		1978	
H/C MAP :	243A	OYSTER LEASE MAP	05	1984	

NAV CHART : 1341 NAME : LITTLE LAKE MONIKER:
SCALE 1: 8000 INTERVAL: 1" = 6666.7ft, 2032.0m, 2.032km

ADJACENT MAPS:	GROUND DISTANCE TO BOUNDARY	MAP DISTANCE TO BOUNDARY
SOUTH	1.03mi = 1.66km	.82in = 20.8mm
SOUTHEAST	14.12mi = 22.72km	11.18in = 284.0mm
EAST	14.08mi = 22.66km	11.15in = 283.3mm

SOURCE	CMD #	NAME	MONTH	YEAR	P.R.
H/C MAP :	1341	NAV CHARTC	12	1984	

LANDSAT DATA: permit is SOUTHEAST OF APPROX. CENTER OF 29.5230 , 90.2713
name : LEEVILLE & LITTLE LAKE date : 12 021984 cmd#: 0007
id = Y5027616022X0 quad = 1 path = 22 row = 40 dg tape 143

PHOTOGRAPH SERIES NASA85 SEARCH RADIUS = 19.59 mi
SCALE 1: 65000 INTERVAL: 1"= 5416.7ft, 1651.0m, 1.651km

CMD#	ROLL	FRAM	MM	YEAR	SCALE	LATITUDE	LONGITUD	TY	F	SERIES	DISTANCE
	03549	1347		1985	65000	29.3839	90.2217	IR	N	NASA85	2.17
	03549	1346		1985	65000	29.3819	90.1697	IR	N	NASA85	3.30
	03549	1348		1985	65000	29.3797	90.2747	IR	N	NASA85	4.49
	03549	1212		1985	65000	29.4839	90.2208	IR	N	NASA85	4.86
	03549	1211		1985	65000	29.4842	90.1697	IR	N	NASA85	5.43
	03549	1213		1985	65000	29.4872	90.2683	IR	N	NASA85	6.11
	03549	1345		1985	65000	29.3825	90.1131	IR	N	NASA85	6.24
	03549	1210		1985	65000	29.4842	90.1172	IR	N	NASA85	7.41
	03549	1349		1985	65000	29.3770	90.3272	IR	N	NASA85	7.42

AREA SUMMARY FOR 1956 IMPACT CIRCLE   ACTIVE MAP NO. 4

SUBJECT	AREA	FREQUENCY	PERCENT
E1OWO.	11.14	1	2.22
PEM.	461.75	2	91.97
USS13S.	29.19	2	5.81
TOTAL (IN ACRES)	502.1	5	100.00

AREA SUMMARY FOR 1978 IMPACT CIRCLE   ACTIVE MAP NO. 5

SUBJECT	AREA	FREQUENCY	PERCENT
E1AB2.	401.11	4	79.89
E1OWO.	36.04	2	7.18
E2EM5P5.	24.21	4	4.82
USS1S.	40.70	4	8.11
TOTAL (IN ACRES)	502.1	14	100.00

AREA CHANGES FOR 1956 TO 1978 HABITATS

ID	VALUE	AREA	FREQUENCY	%	56--SUBJECT--78	
1	2.1000	392.85	15898.0	78.27	PEM.	E1AB2.
2	2.3000	24.02	972.0	4.79	PEM.	E2EM5P5.
3	2.4000	28.34	1147.0	5.65	PEM.	USS1S.
4	3.4000	8.99	364.0	1.79	USS13S.	USS1S.
5	3.1000	9.02	365.0	1.80	USS13S.	E1AB2.
6	1.4000	2.74	111.0	.55	E1OWO.	USS1S.
7	1.2000	8.45	342.0	1.68	E1OWO.	E1OWO.
8	3.2000	10.97	444.0	2.19	USS13S.	E1OWO.
9	2.2000	16.56	670.0	3.30	PEM.	E1OWO.
TOTAL ACRES		501.9	20313.0	78.37	(138.6 ACRES BACKGROUND)	

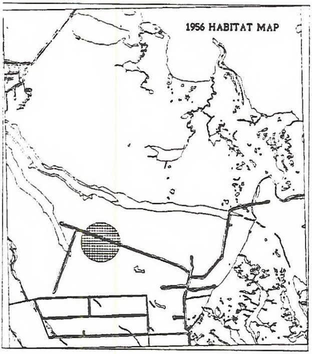
AREA SUMMARY FOR ECO ATLAS ACTIVE MAP NO. 12

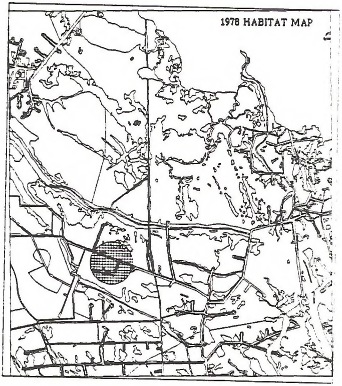
SUBJECT	AREA	FREQUENCY	PERCENT
H2OFOWLC	422.29	1	92.03
SENSITIV	36.56	1	7.97
TOTAL (IN ACRES)	458.8	2	100.00

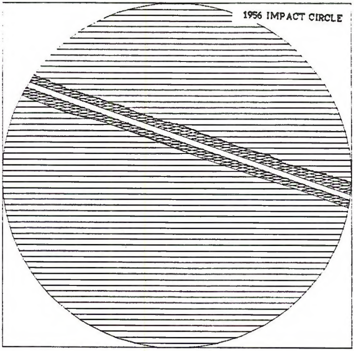
SUMMARY FOR MAP TER86PTMAP PERMIT LOCATIONS

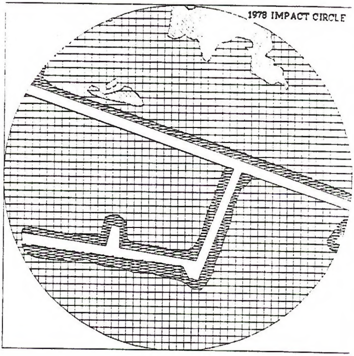
I.D.	CUPNO	NAME	ACKNOWL	PARISH	ST	PERMTYPE
555	P851438	CIMARRON	851105	LAFOURCHE	4	110 0 0 10
560	P821301	DAVISOIL	820902	LAFOURCHE	4	11099 0 00
569	P851189	SOUTHPORT	850911	LAFOURCHE	4	11

AUTOMATED PERMIT ANALYSIS SYSTEM OUTPUT







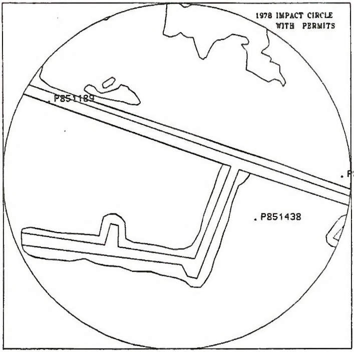


AUTOMATED PERMIT ANALYSIS SYSTEM OUTPUT

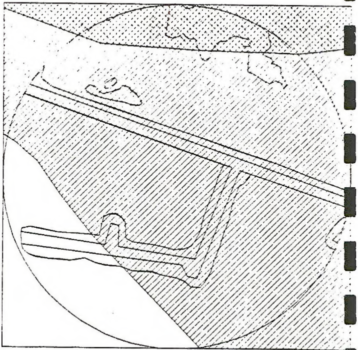
DECISION ASSOCIATES AUTO PTS
19-SEP-86 16:09:30
REVIEWER : STREIFFER
PERMIT # : P860530
LAT LON CORD: 29-24-50 90-12-39
UTM COORD. : 770636.5 3256901.5
PROXIMITY : 0.5
HABITAT MAP : GLDMF78HAB
PERMIT MAP : TER86PTMAP
ATLAS MAP : TER81MERG3

HABITAT SHADE PATTERNS

- WATER
- FRESH MARSH
- INTERMEDIATE MARSH
- BRACKISH MARSH
- SALINE MARSH
- NON-FRESH MARSH
- UPLAND FOREST
- BOTTOMLAND HARDWOODS
- SWAMP
- SHRUB/SCRUB
- AG/PASTURE
- DEVELOPED
- AQUATIC VEGETATION
- INERT
- UNASSIGNED



ENVIRONMENTAL SENSITIVE AREAS SHADED



THE IMPLEMENTATION OF A REGIONAL ATLAS TO SUPPORT THE LONG TERM MONITORING REQUIREMENTS OF THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

By:

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ABSTRACT

The National Acid Precipitation Assessment Program is a multi-agency effort of the federal government established to determine the adverse affects of acid precipitation and related atmospheric pollutants on the ecosystem. One task of this effort is to develop and implement a long term monitoring system to assess the affects of these pollutants on the nation's forests. It was the consensus of opinion among key scientists from across the country that information concerning the location of areas of forest vegetation potentially stressed by either pollutant induced or natural processes was essential for developing the stratification and sampling scheme necessary to implement the long term monitoring system. It was decided that an interactive "atlas" containing spatial information which permits investigators to locate forest areas where stress is likely to occur was essential for meeting the program objective. Originally, the system was envisioned as a dynamic electronic atlas operating on microcomputers at individual research locations, with results shared among investigators.

Initially, the atlas concept is being implemented by the USDA Forest Service, Southern Region, Forest Pest Management Staff Unit, on a dedicated Data General MV 4000 minicomputer using the MOSS family of software products. The thirteen southeastern states are the initial geographic extent of the atlas. Weather, timber, soils, and atmospheric deposition have been identified as the four primary data themes necessary to implement the atlas concept. Assembling the data from these diverse data themes has required ingenuity and the development of specialized data manipulation software. The weather data for the atlas will include data from more than 100 airways weather stations spanning a time period of 30 years. Initial atmospheric pollutant data covers a 5-year period, from 1980 through 1985. Data in these two data themes are tabular records linked to station coordinate locations. County estimates of growing stock volume and type acreage provide the forest location data. The soils data, digitized from state generalized soils maps, was included to support the assessment of forest stress. Available moisture capacity to a depth of 40 inches is the first stress related soil variable. Initial data loading and entry has been completed for timber, atmospheric, and soil data themes. Because of the large volume of data entry, the weather data is still in progress.

The project represents a unique approach to multidisciplinary research and presents the first exposure of a wide spectrum of research scientists to geographic information system technology and the MOSS family of software products.

INTRODUCTION

Throughout geologic time plants and animals have acted to modify the earth's environment and atmosphere. Until recently these changes occurred slowly over the span of thousands of years. Over the last two centuries, however, human activities have altered the earth's chemistry in ways which may cause staggering ecological and economic consequences. The National Aid Precipitation Assessment Program (NAPAP) was established in 1980 under the statutory authority of Title VII of the Energy Security Act (PL 96-294). "The goal of the National Acid Precipitation Assessment Program is to develop a comprehensive information base on the causes and effects of acidic deposition and to provide methods for effective management of the problem."

The Forest Response Program was established under the NAPAP (terrestrial effects) Task Group to answer three broad policy questions.

1. Is there a significant problem of forest damage in North America which might be caused by acidic deposition, alone or in combination with other pollutants (e.g., SO_x, NO_x, O_3, H+, metals, H_2O_2, or hydrocarbons)?

2. What is the causal relationship between acidic deposition, alone or in combination with other pollutants, and forest damage in North America?

3. What is the dose-response relationship between acidic deposition, alone or in combination with other pollutants, and forest damage in North America?

Each of these broad policy questions has been translated into a set of scientific questions. The National Vegetation Survey Program Support Atlas is being implemented to serve as a tool for answering scientific questions posed for policy issue.

1. Are changes in forest conditions greater than can be attributed to typical trends and levels of natural variability?

2. What spatial patterns, if any, exist in forest conditions, and how do these patterns relate to the spatial patterns of pollutant exposure?

OBJECTIVE

Our objective in implementing the National Vegetation Survey Program Support Atlas is to provide program management and investigators with the spatial data and analysis capabilities necessary to support the definition, implementation, conduct, documentation, and reporting of activities conducted to determine the impact of atmospheric deposition and other stress factors on the growth and yield of southern commercial forests. The term atlas, i.e., a collection of maps, does not clearly describe the guiding concept of this effort. The scientists who developed the project believed that an understanding of the interrelationship among stress factors and the location and physiological condition of the forest was essential for meeting program objectives. They envisioned a capability to perform spatial display and analysis of variables related to stress factors and tree physiology that would provide an understanding of the interrelationship between these data elements. This capability could then guide the development of sampling strategies for objectively quantifying the impact of atmospheric deposition and other stress factors on the forest. To be effective, the Program Support Atlas must be available to a wide range of investigators. The data base must be updated as

new information becomes available. As new hypothesis are advanced, additional spatial analysis models must be implemented. Personal computers have been targeted for eventual distribution of the Program Support Atlas software and data. The implementation of the Program Support Atlas is a challenge to both computer technology and our capability to conduct effective interdisciplinary research.

SELECTION OF PROCESSING SYSTEM TECHNOLOGY

Three basic classes of computer systems capable of manipulating spatial geographic information were considered for implementing the atlas project.

Computer aided mapping (CAM) systems are intended for the development and updating of printed maps. These systems have special capabilities for placing the type and symbols common on printed maps. They do not, however, recognize line segments as components of spatial entities, nor do they posses the computational capability necessary to implement the Program Support Atlas.

The second class of systems could be generally described as map display systems. In these systems, a series of attributes or variables are linked to a geographic entity. Population and median income, for example, might be linked to a series of coordinate values that describe county boundaries.

The third class of systems, Geographic Information Systems (GIS), have a data structure similar to map display systems. The primary difference between the two classes of systems is in the extent of their analytical capability. A map display system is limited to numeric and logical calculations on the attributes attached to each geographic entity. A GIS is capable of analyzing both the spatial and attribute data. Both systems could display all counties with a population of over 100,000 and a median income of over $10,000. A GIS could, in addition, operate on the cartographic entities and determine, for example, the distance of these counties from interstate highways. Because GIS systems can operate on spatial data, they are capable of analyzing data from more than one data theme simultaneously. They can answer questions such as: where are counties with over 100,000 cubic feet of loblolly timber per acre that experienced excessively low spring rainfall in 1985 located. GIS technology was chosen to support the implementation of the Program Support Atlas because of its capability to both analyze spatial data and tabular variables.

The Map Overlay and Statistical System (MOSS), a public domain GIS operating on a dedicated Data General MV 4000 minicomputer operated by the USDA Forest Service, Southern Region, Forest Pest Management Staff Unit, was selected for initial implementation of the Program Support Atlas. The system includes two digitizing stations with graphic terminals, a color graphic display station, an image display station, and text terminals. An eight-pen ploter provides map output products. The system includes 592 megabytes of fixed, and 192 megabytes of removable disk storage capacity, along with a high density tape drive.

PRIMARY DATA DIVISIONS

A multidisciplinary panel of scientists initially identified four primary data divisions necessary to meet the objectives of the project.

(1) Weather
(2) Soils
(3) Atmospheric Deposition
(4) Timber

In addition, it was decided to initially limit geographic coverage to that portion of the thirteen southern states extending south from Virginia,

Kentucky, and Tennessee, west to Texas and Oklahoma, and east of the 100th meridian. Assembling the data for each of the data divisions has been a significant task. The data for each atlas data division have been prepared by investigators with the discipline, specific knowledge, skills, and capabilities necessary to assemble the required data. The following sections were extracted from descriptions prepared by the scientists responsible for assembling the data for a recent program review. These scientists were responsible for the data for the atlas data divisions:

DATA DIVISION	INVESTIGATORS	AFFILIATIONS
WEATHER	Dr. James Paul Ken Forbus	USDA Forest Service Southeastern Forest Experiment Station Macon, Georgia
Soils	Dr. J. R. Jorgensen Kim Ludovici	USDA Forest Service Southeastern Forest Experiment Station Research Triangle Park North Carolina
Timber	Dr. Roy Beltz	USDA Forest Service Southern Forest Experiment Station, Starkville, Miss.
	Joseph McClure	Southeastern Forest Experiment Station Asheville, North Carolina
Atmospheric Deposition	Dr. Al Lefohn	ASl Associates Helena, Montana
	Dr. Rudolf Husar	Trend Analysis Group Clayton, Missouri

Weather

Tree growth is the result of complex integrations among many physical, chemical, and biological processes. Weather is the major and most uncontrollable factor influencing tree growth. Unfortunately, there is no definitive model that uses weather to predict tree growth. In the absence of a weather-driven tree growth model, it was necessary to identify from the literature the weather variables and their averaging periods for use in the atlas. Furthermore, since trees have evolved over the years in response to weather, then it seemed logical to describe the weather variables as deviations from the long-term average. It should be noted that this undertaking far exceeds any previous attempt in the United States to define and summarize weather in this fashion over such a large area (530 million acres).

Weather variables and sources being included in this atlas are:

1. Dry-bulb temperature (maximum and minimum)
2. Precipitation
3. Relative humidity
4. Cloud-cover
5. Dewpoint temperature
6. Wind direction
7. Wind speed
8. Vector wind average
9. Visibility (fog, smoke, etc.)
10. Turner stability class (i.e., atmospheric stability)

Each variable will be represented as monthly averages and deviations from the 10, 20, or 30 year average. The source for all input data for all variables is the National Climatic Data Center in Asheville, North Carolina. Hourly surface observation, summary of the day, and hourly rainfall data were obtained from the available stations in the region. The hourly surface data (airways) require extensive decoding and reformatting. For example, the decoding of one airways station for the period 1945-1983 requires about 4 hours on an IBM 370-148.

Airways data is surface weather collected hourly at airports. Data from 120 such stations will be decoded and analyzed. Data to be electronically stored include the raw sums, cross products, and frequency information by hour, month, and year. Hourly rainfall data will be obtained from the airways data set and from over 840 other rainfall-measuring stations in the region.

<u>Soil</u>

Next to distribution and amount of rainfall, the capacity of soil to hold and gradually provide sufficient moisture is most important for tree growth. Available moisture capacity (AMC) of soil depends primarily on texture, organic content, depth of each horizon, and volume of soil available to tree roots. Available moisture generally increases with organic matter content and, to a point, with a decrease in particle size. Clays may have a high total moisture-holding capacity, but only moderate AMC. Furthermore, density and structure of some silty and clayey soils restrict root growth and prevent complete utilization of available soil moisture. Similar restrictions to root growth, such as pans and other compact layers, water tables, and rocks, can reduce the effective rooting volume from which moisture can be obtained.

Acidic deposition may also affect productivity of certain soils in the South. Certain soil characteristics can be used to predict a soil's sensitivity to acid deposition. Soil sensitivity to these stresses should be assessed and put in atlas format. Soil parameters chosen for the sensitivity interpretation were AMC, surface ph, ph at 40 inches, percent organic matter, percent clay at the surface, and percent clay at 25 inches.

<u>Data source</u>: General soil maps were obtained from the Soil Conservation Service for each state in the South. Data on the selected soil parameters were gathered with the assistance of the Soil Information System (SIS), a division

of the Environmental Technical Information System (University of Illinois, Urbana).

State soil maps are typically divided into Multiple Land Use Areas which are further divided into Soil Associations. Soil Associations contain from one to four individual soil series with the listed soil series making up at least 70% of the Association. Calculations began with the smaller soil groups.

Equations for final calculations of Soil Associations were based on the range for each individual soil series and on the proportion of that series in the Association.

Timber

Forest surveys have been conducted periodically by Forest Inventory Analysis (FIA) units in the USDA Forest Service since the passage of the McSweeny-McNary Act in 1928. Subsequent legislation has expanded the role of the Forest Survey but its basic mission remains and its data sets are the most consistent and contribute the most detailed descriptions of forest resources in the United States. To coordinate the use of the various atlases, it is imperative that the geographic location and frequency (growing stock cubic volume and forest area) of the important tree species and forest types in the southern region be displayed.

FIA units from the Northeastern, Southeastern, and Southern Forest Experiment Stations supplied county data for this atlas. All the definitions and procedures used by the various FIA units involved are closely aligned to assure compatible resource estimates. Since surveys are conducted continuously in the South, and in a cyclical fashion, the dates of the surveys vary by state. In each state, the most recent survey data will be depicted. The date of survey will be shown for each state. As new surveys are completed, new information will become available for incorporation into the atlas.

Surveys were originally designed to provide reliable estimates of forest area and volume at the state level. The data are commonly used for smaller areas but reliability falls off rapidly as the focus of interest narrows. Individual county estimates are subject to sampling errors of about 3% for area and 15 % for volume. Smaller counties, counties with little forest area, or highly variable conditions due to topography, etc., will have even larger sampling errors. County estimates are useful, however, for accumulating estimates for larger areas and for displaying geographic distributions of various forest resource parameters.

Data sets with county value can be used to show the distributions and the relative frequencies of occurrence of the most important species in the region. The atlas will show growing stock volume for the major commercial timber species and areas for the major forest types in the South.

Atmospheric deposition

Air quality, wet deposition, and haze data for the South were obtained and characterized from all primary data sources: (1) United States Environmental Protection Agency (SAROAD), (2) Electric Power Research Institute (SURE and ERAQS), (3) Tennessee Valley Authority, and, (4) National Park Service. Prior

to characterizing the ozone, sulfur dioxide, and nitrogen dioxide hourly mean concentrations, the USDA Forest Service, Southern Region Forest Pest Management Aerial Survey Team (Atlanta, Georgia) obtained aerial photographs of the 640 monitoring sites and made comprehensive photo interpretations (2.5 mile radius by quadrant) of the relevancy of the sites to forest areas. Data have initially been provided for a site subset of the original 640 sites based on photo interpretation criteria.

Monthly characterizations of ozone were : (1) 7-hr average (0900-1559); (2) number of hours that make up the 7-hr average per month; (3) number of occurrences $\geq$ 0.06, 0.08, 0.10, 0.12, 0.14, and 0.15 ppm; and (4) number of reported hours per month. Monthly characterizations of sulfur dioxide and nitrogen dioxide data were: (1) number of occurrences $\geq$ 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, and 0.08 ppm; and, (2) number of reported hours per month.

For characterizing wetfall deposition and concentration in the region, precipitation chemistry data were obtained from (1) the National Atmospheric Deposition Program (NADP), (2) the Multistate Power Production Pollution Study (MAP 3S), and, (3) the Utility Acid Precipitation Study Program (UAPSP). A total of 57 stations are available within the region.

Wetfall data from each precipitation chemistry station were used to calculate monthly and annual concentrations and deposition of sulfate, nitrate, calcium, hydrogen ions, and ammonium. The deposition information was reported in milliequivalents per square meter/year. Concentration information was reported in microequivalents/liter. These values can be easily converted to more meaningful biological values such as kg/ha and mg/liter of rainfall, respectively. Special attention was given to the procedures of data handling for records that contained missing data.

Visibility, or visual range (kilometers), is the furthest distance at which an object can be discerned by the human eye. Atmospheric visibility observations by a human observer are made at all major meteorological stations, including airports. Visibility data collected at meteorological stations have severe limitations. Prior to any statistical or other analysis, it is essential to scrutinize and make the appropriate corrections. The extinction coefficients are calculated from values of visual range recorded routinely by human observations as part of a global meteorological network. Eliminating the data during rain, snow, or fog, and performing a relative humidity correction, one obtains a visibility parameter that primarily depends on man-made haze. Long-term trends of such corrected visibility data reflect the trend of man-made haziness. It is more convenient to show the trend of the inverse of visual range or haziness rather than by the visual (i.e., the atmospheric extinction coefficient) range itself. The extinction coefficient is closely related to the concentration of materials in the air that cause light scattering and absorption. Hence, the coefficient is more appropriate than visual range for use in trend and spatial analysis. Visibility data were obtained from 44 monitoring sites in the South over the period 1948-1983.

ASSEMBLING THE DATA BASE

It has been a formidable task to bring together the diverse data in the four primary data divisions into a common structure acceptable for GIS analysis. Three types of software in addition to the standard MOSS utilities were used in

assembling the data base: (1) AOS/VS utility software, (2) Generalized record manipulation data base software written by project personal (Record Keeper), and, (3) specialized task specific record manipulation software. The latter two classes of software were written in BASIC.

The principal challenge in preparation of the attribute data arose from the lack of uniformity in input materials. Data was referenced in reports, provided on handwritten code sheets, IBM PC diskettes, and computer compatible tapes in both ASCII and EBCDIC character sets. In some cases, the "flat files" were actually reports written to disk which included headers that had to be stripped and fields that did not line up. To insure uniformity, we requested the use of standard, two-character, US Postal Service codes for state identification. The substitution of incorrect postal codes by some investigators resulted in the software inserting the FIPS code for the Virgin Islands (VI), rather than Virginia (VA) in the data record, until the program was modified. Where the data had been extracted from a national data base, the files often had to be restructured.

Our approach to developing multiple attribute or ADDWAMS point files from data sets provided by investigators includes five steps.

Step 1. Create a flat file using data set specific software. Data set specific software can easily be developed in BASIC. It can be used to perform functions not easily accomplished with Data General utilities such as Sort/Merge or SED. The software also documents modifications made in the data set. Examples included joining physical records so that each logical record exists on one physical record, stripping header records from report format data, and editing state identification codes.

Step 2. Define a Record Keeper data base conforming to the flat file data structure. The Record Keeper is a data base program written originally for the Apple II by one of the authors (Uhler) that is currently being rewritten for the Data General AOS/VS environment. The data in Record Keeper data bases are stored on ASCII flat files. Existing flat files can be accessed after the field structure has been defined using the Record Keeper data base definition function.

Step 3. Sort subset and compute additional fields using Record Keeper to modify the initial flat file. The data required for a specific map generally represents a subset of the data provided by the investigator. A weather data set, for example, consisted of records with fields for station identification, station location (latitude, longitude), month, year, average rainfall, actual rainfall and deviation from the average. The records covered the period from 1980 to 1985. We were asked to develop a map showing the deviations in the spring (March, April, May) of 1981 rainfall from the long term average. In this case Record Keeper was used to extract records for the relevant months and year, sort the records by site and month, and compute fields for total spring rainfall, total normal rainfall, mean normal rainfall, and the difference between actual and normal spring rainfall.

Step 4. Create multiple attribute definition and data files and/or ADDWAMS point data files using utility programs developed on-site using, for example, the requirement described in Step 3. The "create" on ADDWAMS function would be used to create a file in standard format. The user has the option of

specifying the Record Keeper fields to be included in the subject. The coordinate values in the Record keeper data base are specified by location and can be in either DDD:MM:SS or decimal degree format. A second function can be used to automatically create a MOSS attributes definition file. This utility uses the formation stored in the Record Keeper data base definition as input to create the MOSS attribute definition file.

Step 5. Incorporate the data into the MOSS GIS using MOSS ADD and utility attribute commands. Using the appropriate commands, data prepared using the previously described procedures can be added to a MOSS data base.

CURRENT ACTIVITY

Input of data covering the Southern Region has been completed for the Atmospheric and Timber data division. With the exception of Oklahoma, where no soils map suitable for digitizing is available, the soils data division is complete. Preparation of the Weather data is scheduled for completion in June, 1987.

A three-state subset (Georgia, North Carolina, and South Carolina) of the regional data base is being used to develop demonstration maps and models. Twelve maps were developed for a recent program review. Point data were interpalated to a 10,000 meter grid using the inverse righted distance option of the MOSS GRID command. We anticipate using the kriging and masking options of the GRID command to produce maps in the future.

The forest Weather and Atmospheric data divisions will be updated annually. The current soil data derived from existing generalized state soils maps will be replaced by the new USDA Soil Conservation Service STATSGO soil geographic data base when the digital data has been released and interpretations have been completed. We anticipate replacing the USDA State and County data base with the USGS 1:2,000,000 digital line graphic (DLG) data. Over the next year we will add a data division that will present the distribution of major forest pests and fire disturbance.

Assembling the data, although a difficult task, is only the first step in meeting the objectives of the Atlas Project. Developing GIS analysis procedures and models that adequately describe the distribution of pollutants and the physiological status of the forest represents the next major challenge of this project.

A Collateral Image Processing Technique for the MOSS Family.

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ABSTRACT

Image processing techniques have seen increasing popularity as tools for deriving useful geographic information. This trend will continue to expand as image processing hardware and software become less expensive, and more common in the workplace. Designers of geographic information system software today are in a position to incorporate imagery and imagery analysis tools into their software and database structures if they so choose. Systems that were developed without image processing considerations, however, can be difficult to re-design to incorporate the new data models and image processing software. Although the MAPS component of the MOSS family can import raster data from a remote sensing source, MAPS does not support the exploitation tools that allow realtime multi-channel image analysis. This report will detail an example of successfully linking AMS, MOSS, and MAPS to an existing image processor with very few modifications to the applications software, and no changes to the database structure. This report will also detail some of the powerful new tools that resulted from combining these two technologies.

INTRODUCTION

The MOSS family of software has evolved over the last few years into a very capable and adaptable geographic tool. MOSS, AMS, MAPS, and some of the other members of this family can be found on a wide variety of computers servicing an even wider variety of output peripherals. The flexibility and adaptability of the MOSS family software has contributed largely to its success and popularity.

Image processing technology blossomed with the arrival of low cost computing hardware. Recently, the proliferation of mini and personal sized computer based image processors has been staggering. Relatively low cost image processing has now become a reality.

Unfortunately, the MOSS family of GIS products and image processing products arose independently, such that neither can currently use data from the other with much utility. This has been true for many GIS packages and image processing packages, but the trend now is to design integrated systems that can reap the benefits of both. Where does that leave the MOSS user community who want imagery considered as a source of geographic capture and display? This was a question we asked about a year

ago when we considered how we could get AMS and MOSS to use an image processor.

DESIGN PHILOSOPHY

The first inclination was to re-design the databases used by AMS and MOSS to handle multi-channel raster data. Needless to say, this would have involved extensive coding and cost. Another approach was to create an intermediate format that could be imported or exported by either system. The problem with that approach was that it was far too inefficient in that data was duplicated excessively. This approach also suffered from the problem that it rapidly became very device specific - one of the items that we wanted to avoid when we were working with MOSS family software.

We finally came up with the idea to simply build and maintain a mathematical link between the two systems, and to treat the image processor and the math model as a new MOSS family peripheral. The only software needed was that to establish the math model and apply it to the data. Modifying AMS and MOSS application software was going to be costly, so we decided to modify a section of the "choke point" between the applications software and the graphics devices. Figure One indicates this. Some of the advantages to this approach are that the data sets would never actually have to meet, applications software would not be heavily altered, the approach would provide a "real time" access to the display screen's data (versus a batch approach), and that most image processing packages have software that lets you treat the display like a graphics peripheral.

The next step was to benchmark some potential math models. We selected an eight parameter polynomial, as it was the most robust of the models tried, and the easiest to use. (It does have the disadvantage, however, of not being able to handle cases where terrain relief is expressed as horizontal shifts in the imagery.) To this date, the technique has been used successfully on Landsat TM, MSS, digitized airphoto, and Large Format Camera Imagery.

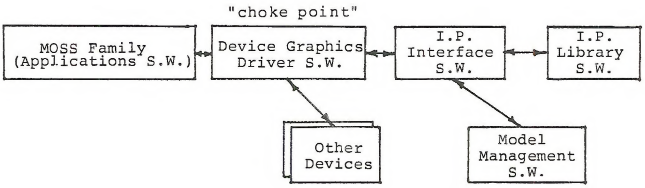

Figure One

SOFTWARE COMPONENTS

This section of the paper details some of the suggested and potential software components that could be used to provide an image overlay capability. First, the basic components will be addressed.

There are only two basic software links that need exist between the GIS applications software and the image processing software. They are: a read screen position from cursor, and a write color to screen position capability. With these two capabilities a generic image overlay tool can be developed. The advantage of restricting to just these two links is that these represent functions that can be found on almost any image device and its controlling software.

The more complex image processing systems and software, however, usually support a much broader range of image processing and control options to the programmer. The temptations to allow applications software to access these capabilities must be checked if portability of the software is a consideration. One way of preserving these two simple links yet still taking advantage of some of the other features of the image processor is to add the additional functionality into the poll or display routines. This way, the applications software is not disturbed. An example of this technique would be allowing the trackball/joystick to scroll or roam through image memory when the applications software calls for a digitizer input. Similarly, trackball buttons could be exploited during a poll sequence to indicate conditions (like digitizer mouse buttons) or to toggle items such as channels or the image device's zoom register. The disadvantage of this approach is that access to zoom/scroll and other embedded functions is only facilitated during applications software digitizer reads. This is more than made up for by the fact that applications software will not have to modified to control zooming, scrolling, or certain toggling functions.

If one were to relax some of the strict portability rules and maybe even alter small portions of the application software, many other image processing related tools could be exploited for use in the GIS imagery overlay environment. These functions have particular potential:

- Graphics plane erasure
- Color look up table management
- Screen clear
- Screen load
- Flood and fill of polygons
- 3D perspective viewing
- Hidden line removal
- Intrinsic character generators
- Hardware warping

In addition to the image processing/applications interface software, several other modules prove useful. These model management utilities include model generation software, model storage/retrieval software, model test and evaluation software, and display graphics driver model control software. With the

exception of the last module, these tools should reside outside of the applications software area as denoted on Figure One. They should, however, be made available from a main menu as a single options or as a set of options.

The model generation software component's task is to assemble a workable mathematical relationship between the GIS's internal reference system and the image's coordinate system. This is usually effected by gathering sets of coincident points from the geographically based GIS and image coordinates (via screen coordinates) from the display device. In the case of polynomial solutions, a set of coefficients is then solved for. We found it to be of particular benefit to the operator if a normal digitizer registration were performed on a map mounted on a digitizing table next to the image display screen. This simplified the task of measuring coincident points as the operator could easily match a feature to its screen representation. It is important that the first measurement of each set come from the image screen, as if there are any cursor mobility restrictions caused by the screen being a grid of a fixed number of measurement points, this restriction should occur to the first measurement as a digitizer affords nearly unlimited measurement points. Model generation software should be flexible enough to allow the operator to manually enter geographic or image measurements or have the software ingest them from a file. The operator should also be able to indicate choice of model and to view the mathematical residuals of a model generation attempt.

Following successful model generation, software should be provided to store accepted coefficients for future or repeated use. Model retrieval should also be provided.

Model test and evaluation software is also very useful, and can be designed to be a very diagnostic package. The function of the model test and evaluation program is to examine the geographic extent of a model's goodness of fit, and acceptability for GIS overlay display and digitizing. This can be done several ways. Tabular statistics, graphic depiction, and interactive polling are examples of useful techniques.

The last major section of related software components is the display graphics driver model control software. This set of software exists in the device driver level of Figure One and is responsible for routing logic flow during a digitizer poll or display call to the image processor software call and through any set of model coefficients.

RESULTS:

The techniques discussed in this paper were fielded on Autometric's 32 bit VAX/VMS version of AMS and MOSS. The image processor used was a Gould-DeAnza FD5000 512x512 device controlled by Gould's Minilips library of image processing software. This section of the paper details some of the exciting products and capabilities that resulted from the mixture of these

powerful tools.

The products and capabilities that were generated when the MOSS family components were mixed with an image processing device fell into three broad categories: masking, exploitation, and product generation.

Masking:
When MOSS was using a model to warp output graphics over a displayed image it became immediately obvious that we had a very powerful tool for creating positive and negative image masks. Positive image masks refer to the ability to use the GIS to itemize areas of the image that are pointed to. This application could be useful if it were used to optimize image processing by delineating areas of interest. An example of this could be the selection of all areas that MOSS knows to be aircraft parking areas (from subject names, context, or multiple attributes), and submitting just these areas of the image to a change detection or pattern recognition algorithm designed to remotely monitor military aircraft traffic. Negative masking is also useful. A negative mask shows all areas not to consider. An example of a potential use of this technique would be using MOSS to mask out all land areas for a study of thermal patterns in a water body.

It could be argued that correctly classified imagery could also perform such masking functions. In many cases it can, but this gets more and more difficult as the limits of spectral classification are approached, and impossible when targets are selected that have little of no imagery manifestation - such as political boundaries, cultural attribution, and many subsurface items. The contextual domain is especially exciting when placed over imagery. When proximity, adjacency, and buffer zone generation within MOSS are used as image masks, very complex masks can be generated suitable for use in many arenas. In short, MOSS´s complex geographic query, combinatorial, and synthesis functions can be used to guide the dissection or concentrate the examination of images.

Exploitation:
The GIS/imagery overlay and capture environment described in this report had a major positive effect on the operator´s ability to exploit the imagery. Although imagery exploitation was mainly boosted in AMS, MOSS also contributed. The increased facility can be broken down into two areas of impact: data capture and imagery analysis.

Data capture was greatly enhanced by having the imagery context available while digitizing. The workstation design included the ability to toggle between registered devices, in our case, a table digitizer with a mounted map and the image display tube. This arrangement allowed for the best of both products to be exploited. Features such as political boundaries and precise road centerlines could be digitized off the map, then imagery dominant features like vegetation and thermal plumes could be

captured off the screen. Data capture was further enhanced by having a common capture and display surface. By displaying the contents of the GIS database onto the image display tube prior to and during the digitizing process it was immediately obvious to the operator what had and hadn't been collected yet. Furthermore, revisiting previously capture items such as nodes became very easy because the graphic representation of that node was on the digitizing surface. One final enhancement to data capture was the ability to have softcopy processes flag areas that the operator might want to examine to update the GIS database. An example might be a softcopy change detection algorithm alerting a digitizer operator to a change that it felt was important. If the digitizer was an analytical stereoplotter, the stages could be driven to the points of interest for closer examination.

Just as data capture was enhanced by the GIS/imagery juxtaposition, so was image analysis. The immediate benefit was the ability to identify features on the image by placing a map symbol on top of or near them. This proved especially true for linear and point features that were partially occulted by vegetation, clouds, or other spectral influences. Often, just the accurate positioning and identification of certain key items allowed the eye to interpolate the location and nature of other nearby items. This was extremely useful for control point generation in areas of enigmatic spectral return. AMS's mensuration utilities were well received as they allowed the analyst to measure locations, areas, distances, and azimuths directly off the image display screen.

Often, the result of a GIS/imagery overlay was an end in itself. The pleasing and useful combination of imagery and GIS information with its associated annotation was a desirable product. Screen capture photographic devices should be considered when designing or installing GIS/imagery overlay capabilities.

CONCLUSION

The futures of image processing workstations and GIS workstations will become increasingly intertwined as the potential for extracting complementary data from each is realized. Many GIS products hitting the market today are attempting to fuse these two data types in an efficient manner, but as with many new products, they are often designed for a particular suite of hardware and software, lack essential GIS or image processing components, or are still prohibitively expensive.

I hope that this paper has shown a fairly simple technique that will allow a widely available GIS software package to utilize some of the advantages of image processing technology without much additional cost or serious modifications to its software. By treating an image processor just like another digitizing and display peripheral with a slightly more elaborate

driver, many of the best benefits of merging imagery with GIS data are effectively realized at a low cost.

Project Development Session

Section 4

STATUS OF GIS AT BLM OREGON

The Bureau of Land Management (BLM) in Oregon has been using Geographic Information Systems (GIS) technology based on the Map Overlay and Statistical System (MOSS) family of software since the late 1970's on a series of projects, such as soil-vegetation inventories. BLM Oregon has recently acquired the largest single Prime 9955-II on the west coast dedicated to GIS processing, with 6 gigabytes of disk storage. GIS technology will be the basis for the upcoming decadal Resource Management Plans (RMP) for five western Oregon BLM districts which are due to be completed in 1990.

In order to begin the 1990 RMP effort, it was necessary to develop new, accurate, uniform base map coverage for western Oregon. The base mapping available to the Districts consisted of a conglomeration of maps at differing scales, vintages, quality and utility, none of which were suitable for modern resource management. The level of detail needed for resource management in the field for daily use is at a scale of 1:4,800 to support activities such as timber sales, road benchmarking and landslide studies. This data is then compiled for use in the RMP process at a scale of 1:12,000. With the development of microcomputer applications in the processing of the stereo-plotted data, this became a cost effective alternative to standard mapping. In order to obtain coverage of BLM's 2.4 million acres in western Oregon a total of 7.006 million acres are being mapped.

The delivery of a stereo-plotted digital data base at a scale of 1:4,800, with x,y, and z coordinates for the eventual development of a true three dimensional capability is a major breakthrough. The cost of the delivered base data from contractors has averaged $0.31 per acre including photography, control, stereo-plotting, and compiling into a GIS/MOSS data file.

The project includes a Public Land Survey System grid (PLSS) created utilizing Public Land Coordinate Calculating System (PCCS) software. PCCS provides the link from the ground control points to the GIS data base at the surveyors level of accuracy, thus creating a high resolution PLSS grid to serve as a base for creation of land status and Master Title Plats. PCCS is verified manually to ground panelled control points and compiled into an MOSS data file.

The base thematic data being captured for western Oregon includes public land survey system, transportation, cultural features, hydrography, gross vegetation and topography at 20 foot contour intervals. Approximately 20 resource themes are being captured, including soils, timber production, land status, elk distribution, and special management areas.

Development of the GIS smart terminal by BLM Oregon as an alternative to expensive high resolution dumb color terminals has led to substantial improvements in both user and data capture processing with peripheral GIS support. The GIS smart terminal consists of an AT level microcomputer with a GIS module including a high resolution 19" color monitor, Tektronix emulator, AutoCAD software and color printer. The smart terminal serves as the basic GIS/MOSS digitizing and editing terminal workstation, having AutoCAD digitizing capability and links to PC-based data base management software programs. It will also operate the new MOSSlite software for PC GIS processing (PC version of MOSS software).

Another development is the Intelligent Cursor video digitizing module. MicroScience Inc. originally developed the Intelligent Cursor as a medical microscanning product. This $7,500 module has been adapted to process data into AutoCAD and MOSS files, replacing planned procurement of a $150,000 laser line follower. Use of the Intelligent Cursor has reduced manual digitizing time by a 3:1 ratio. Resource data already mapped on aerial photos can be captured directly which will further increase savings.

GIS processing was documented to establish time and costs to project the level of effort needed to accomplish the project within RMP timeframes. Many resource themes which were digitized manually will ultimately be user-generated, bypassing manual digitizing. This new technology using a systems integration approach to capture resource themes and other improvements will reduce substantially the costs of data capture.

The value of gathering this digital information is already becoming apparent. Resource themes have been digitized showing areas to be cut for proposed timber sales, known elk habitats, and areas targeted as potential recreation sites. When these themes were overlaid with new updated base maps, several potential conflicts were noted. Alternatives can now be developed and analyzed with accurate information on the impacts of logging (area/volumes) and buffer zones established to protect certain areas. By enhancing BLM's base maps, more accurate inventory data is also generated. Accurate data is essential for effective management of the resources, especially with the increased emphasis on multiple use and public interest.

For further information on GIS activities in BLM Oregon, contact Bob Wright, GIS/Operations Chief, P.O. Box 2965, Portland, Oregon 97208, 503-230-7535 (FTS 429-7535). For information on the western Oregon Resource Management Plans, contact Phil Hamilton, Planning Chief, 503-231-6256 (FTS 429-6256), at the same address.

THE 64,000 SQUARE MILE QUESTION:

DATA BASE BUILDING FOR A CHESAPEAKE BAY GIS

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Abstract

EPA's Chesapeake Bay Program (CBP) is a model effort in estuarine management. An agreement signed in 1983 is coordinating the minds and money of both federal and state agencies to restore and protect the once most productive estuary in the United States. The committees and task forces that provide scientific support to the Executive Council of federal administrators and state governors are using a gambit of tools to do their work, from Secchi disk to mathematical models.

The unique CBP management agreement is being used as well to build a GIS data base for the 64,000 square mile Chesapeake Bay watershed. An attempt is being made to identify existing digitized data bases and establish mechanisms to save public funds increasingly being spent on the very expensive data base building process. This paper describes the efforts made thus far and planned to build a regional Chesapeake Bay GIS data base at the CBP Computer Center in Annapolis, MD. Included in the paper will be the results of a March workshop of agencies within the Bay watershed working on data base development, applications, standards, and documentation.

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I. THE CHESAPEAKE BAY DRAINAGE BASIN covers an area of some 64,000 square miles. It encompasses virtually all of Maryland, nearly half of Virginia and Pennsylvania, and portions of West Virginia and southern New York. From Landsat, the Bay proper seems rather small, about 10% of the entire drainage basin. It does however have far reaching influence on millions of people and other species with its arterial network of over 150 rivers and streams reaching out across the land. Its resources range from human food and drinking water, to the livelihood of a billion dollar fisheries industry.

Of the eight major watersheds in the Bay basin, approximately 60% of the freshwater inflow comes from the originator of Chesapeake Bay, the Susquehanna River. About a million years ago, the Pleistocene glacial melt caused the Susquehanna and its tributaries to overlow their banks. The corresponding rise in sea level submerged the coastal river valley to form the Bay, which is about 200 miles long and ranges from four miles wide at Annapolis, MD to about 30 miles at the mouth of the Potomac River. The Bay is relatively shallow, averaging 28 feet. Portions of the old Susquehanna river bed are over 150 feed deep. Fresh water inputs from the tributaries and the influx of salt water from the Atlantic Ocean establish the natural fluctuating limits for life that emerged in the estuary.

II. BAY USE AND ABUSE is often hard to differentiate. The Bay is a complex, diverse ecosystem that reaches farther than its branches of rivers and streams. Water that originates in or eventually enters the Chesapeake is pumped inland, away from its source, and is used for everthing from backyard swimming pools, to industrial processing, agriculture, and drinking water. Sportfishing and recreational boating are favorite individual pastimes. Commercial uses include major harvesting of finfish and shellfish. The Bay also has two of the largest harbors on the east coast at Baltimore, Md and Norfolk, VA. These inlets are havens for industry and transportation, as well as military bases and battle fleets.

These and many more human uses of Chesapeake Bay are taking their toll. Chesapeake deserves some needed R & R, as do many water and other natural resources. That fine line between use and abuse is even more difficult to define when we don't even understand the natural variation in the Bay's health, let alone our effects on it.

Of all impacts on the Bay, human population growth is the overriding factor. Population in the region has nearly doubled since the 1950's. With increases in humans comes increased demand on water use and its resources. A direct result of increased population is the increase in human waste. Sewage treatment plants and solid waste landfills are being taxed to the limits of technology and becoming obsolete faster than funds can be directed to them. Eighteen billion dollars have been identified in the recently enacted Clean Water Act for sewage treatment plant construction and upgrading.

With human population increase comes increases in development. We continue to cover more land with concrete roads, offices and housing, which replaces natural land filtering of rainwater with storm drain outfalls that empty directly into our streams and rivers. Industrial growth likewise matches population increases. Few existing sewage plants are geared to remove the toxic chemicals poured down the drains of manufacturing and processing plants. Worse yet, some industrial wastes that contain heavy metals or other toxic substances are either being poured directly into the water or stored on the land where they eventually leak into groundwater. More human and industrial waste is being recycled, but not fast enough to continue using the dilution solution to rationalize the effects of these point sources of pollution.

Agriculture runoff is proving to be the greatest concern for the Bay's health. Mismanagement of farmland, pasture, and feedlots has caused millions of tons of soil and animal waste to be washed into the streams, and delivered to the Bay each year. In moving water, these nutrients block light crucial for bottom grasses that support a wide variety of species that are critical links in the food chain. Instead, the "fertile" waters cause massive algal blooms that die off and consume precious oxygen necessary to fish. When the nutrients and detritis settle out, they choke off bottom dwelling organisms as well. As more topsoil washes off ag land and pressure to produce increases, chemical additives are being delivered to the Bay with the soil. Fertlizer, pesticide, and herbicide washoff have increased the focus on this non-point source of Bay pollution.

III. THE CHESAPEAKE BAY PROGRAM (CBP) was born of a 5-year study commissioned by Congress in 1975. Numerous studies already existed at the time documenting the negative effects of pollution on the Bay, however they were fragmented and did not address some serious gaps in our scientific knowledge base. In 1976, the Environmental Protection Agency (EPA), in cooperation with other federal, state and private institutions began a concerted effort to study the primary sources of Bay pollution. In 1981 the research phase ended, and for the next two years, the agencies involved analyzed and integrated their findings.

Reports from this scientific research phase verified what alot of people already knew, but more importantly, it initiated a cooperative political management structure to address the problem. In September 1983, chief executives from Maryland, Pennsylvania, Virginia, Washington DC, and EPA signed the Chesapeake Bay Agreement. The parties to the Agreement called for preparation and implementation of coordinated plans to improve and protect the water quality and living resources in the Bay.

IV. CBP MANAGEMENT created by the Bay agreement is headed by an Executive Council comprised of the agreement signers. The Chair of the Executive Council rotates between EPA and each of the agreement partners each year. Their first order of business was to develop a committee and advisory structure that reflected the number of jurisdictions involved and the intricate scientific disciplines necessary to address the Bay's problems.

The hierarchy consists of three committees, the Implementation, Scientific and Citizens committes that advises the Executive Council. The Implementation Committee has five technical subcommittees, the Planning, Modeling and Research, Non-point Source, Monitoring, and Data Management, to advise it. Each committee and subcommittee have representatives from the Bay Agreement organizations. Chairship of committees and subcommittes is spread around the groups involved.

In addition, cooperative agreements have been signed between EPA and other federal agencies that share the environmental responsibility for the Bay. These agencies include the National Oceanic and Atmospheric Administration (NOAA), The Army Corps of Engineers (COE), the Fish and Wildlife Service (FWS), the Geological Survey (USGS), and Soil Conservation Service (SCS). These Memorandums of Understanding (MOU)s were intended to create joint ventures of scientists and managers to make more efficient use of public funds and other institutional resources involving Chesapeake Bay.

V. THE MANAGEMENT GOAL of the CBP is to support and enhance a cooperative approach at all levels of government. As part of each subcommittee's charter, this goal has resulted in attempts to standardize programs to address the Bay's three priority areas: toxics, nutrients, and living resources. A segmentation scheme representative of circulation and salinity patterns divided the Bay into 48 water quality monitoring stations to be sampled by Maryland and Virginia. Funds that are administered by EPA have been used for a wide range of cost share grants for water quality and biological monitoring. Those monitoring grants have resulted in 3 years of data that can be analyzed across state lines.

Implementation grants for best management practices (BMP)s on agcricultural land to keep nutrients and toxics out of the water have been coordinated throughout the region as well. This non-point source program is the largest budgetary item for CBP. It has already resulted not only in saving of tons of pollutants from entering the Bay, but through a broad education program, is proving economical to farmers as well.

Data generated from the above two programs is being used with historical information by CBP mathematical modelers. They will use the data to validate management scenarios that test various baywide pollution control strategies.

The cooperative mangement goal of CBP has also resulted in the development other common management tools, including monitoring methods, data standards and quality objectives, analytical methods, and presentation techniques. It resulted in the creation of the CBP Computer Center, which is the repository of Chesapeake Bay basin data. The Data Management Subcommittee is responsible for the activities of the CBP Computer Center and the development of all data related policies. It is here that GIS technology surfaced as the appropriate data management tool to assist in achieving CBP goals.

VI. THE DATA MANAGEMENT SUBCOMMITTEE AND GIS technology had a shakey beginning in 1984. To many on the Subcommittee, GIS was another wishful solution that cost alot of money to buy, alot of time to support, and alot of computer resources. They were skeptical of "trendy" technology, learning from past experiences in the fast growing computer industry. The Subcommittee is also trying to keep demand down on an already overburdened computer.

Our VAX 11/780, purchased in 1985, supports over 100 users, up to 24 interactive at any one time. Overnight jobs are often still waiting to be executed the next day. Until recently most Subcommittee members agreed that the existing statistical and graphics software were adequate to support the Program's mission.

Arrival of GIS on the CBP scene is due primarily to the efforts of US Fish and Wildlife. In 1985, the Subcommittee sanctioned a pilot project to use GIS technology, but with no budget or equipment, to target non-point source areas on the Choptank River. With that mandate, Jeff Booth and Fred Seavey of Fish and Wildlife went off in search of the only public domain GIS software package, one developed for NASA, called MOSS. By the summer of 1986, it was apparent that MOSS could not do the job, since it had no financial support, kind of like the GIS project given to them.

It was at the 1986 Third Annual MOSS Users Conference that Jeff Booth met Cliff Grieve, president of Autometric, Inc. the developer of MOSS, but now referred to as AutoGIS. Autometric had taken the most recent version of the MOSS software and was enhancing it on a contractual basis. Jeff convinced Cliff Grieve that using the CBP as a beta site for his VAX version of AutoGIS would be good exposure. By October, not only did CBP have AutoGIS installed on the computer, Jeff convinced Altek's Don Cameron to donate a digitizing table to the cause. In the meantime, EPA purchased other necessary input and output devices.

About the same time, CBPs contractor, Computer Sciences Corporation (CSC), primarily Lowell Bahner and Lynda Liptrap, strong proponents of GIS, performed a study of GIS technology and its appropriateness to the Program's goals. I was fresh to the Program and the Subcommittee, as well as to GIS. After hands-on training with MOSS at the University of Missouri, and reviewing the draft CBP GIS Report by CSC, I was a firm believer. Upon editing the CSC report, I took it to the Subcommittee with recommendations to implement a GIS program that included building a digitized data base for the applications already identified, purchasing additional software and hardware, and establishing a regional workgroup to address the obvious and hidden issues inherent in the technology. The Subcommittee approved.

VII. WHY GIS FOR CBP? The primary justification for GIS Technology is that CBP's other mapping (MAPIT) and graphics (SAS, Surface II) software are inadequate for the current program applications.

CBP is in a developmental stage called Implementation Phase II. This stage requires the collection and storage of more spatial data as opposed to point, or parameters that contain multiple, connected points represented by geographic coordinates. For example, defining distribution of a particular species of vegetation or location of the spawning area of a certain finfish in the Bay requires a unique data management tool. A GIS is the appropriate software tool to collect and store this type of data.

The spatial data being collected during Phase II Implementation are required for very specific types of analysis. CBP managers are asking questions that require comparing various types of geographically dependent data. This means being able to search a data base for striped bass spawning areas that are in waters within a range of dissolved oxygen or other survival dependent habitat parameters. A GIS is the software tool to provide this type of analysis of different types of data from various sources, at different scales. Other, more common analytical packages cannot provide this type of geographic based comparison.

CBP Implementation Phase II also requires the ability to display and present the spatial data analysis results in a meaningful, consistent manner to management, Congress, and the public. Graphic representation using multi-color, shaded maps is far more attractive and informative to a non-technical audience than tabular or x,y cordinate line graphs. A GIS is again the software that allows multiple types of data to be displayed on easily recognized base maps.

CBP is a joint effort of federal and state agencies. EPA is behind other agencies with environmental/geographic regulatory missions when it comes to using the appropriate technology. The US Fish and Wildlife Service, US Geological Survey, the Soil Conservation Service, the State of Maryland, and Commonwealth of Virginia are all using GIS technology. Since EPA serves as the lead federal agency of CBP and in environmental protection, we should at least have the tools to communicate with our Program partners, and more often be a leader in state-of-the-art technology. GIS technology that is implemented at the Bay Program can be shared with other EPA programs so that start-up time for future projects can be reduced and lessons learned can be passed on.

VIII. CBP GIS IMPLEMENTATION has mushroomed compared with the time it took to get over the kinetic threshold of resistance. EPA has a full-time staff person for GIS, who is managing a nationwide GIS needs study for the agency. CBP is a now pilot GIS project site that EPA will use to develop agencywide standards for procurement and other policies. In March, CBP held a Chesapeake Bay GIS Conference that attracted nearly 100 representatives from around the region who either already had GIS projects in place or was investigating the feasibility of the technology. Out of that conference, a workgroup was formed of the various federal, state, and local agencies within the basin.

IX. GIS PROJECTS IN THE CHESAPEAKE BAY BASIN

PROJECT NAME: Patuxent Watershed Model

DESCRIPTION: Development of a multi-level (layer) data base for the Patuxent River watershed. Data layers to be included are soils, land use, transportation, hydrologic boundaries, political boundaries, wetlands, public lands, and living resources.

AGENCY NAME: MD Department of Natural Resources
Program Open Space
2012 Industrial Drive
Annapolis, MD 21401

PROJECT NAME: Maryland Automated Geographic Information System (MAGI)

DESCRIPTION: The MAGI system is a comprehensive grid cell based GIS of natural resources data for Maryland. The system provides the capability to retrieve and manipulate various forms of geographic data (i.e. soils, land use, county comprehensive plans, etc.) and display the results as tabular reports and maps. Since its origin in 1974, MAGI has been used extensively by state, federal, and local government agencies, as well as colleges, universities, and private industry to analyze land and water resource data.

AGENCY NAME: Maryland Department of State Planning
Office of Planning Data
301 West Preston Street
Baltimore, MD 21201

PROJECT NAME: STATSGO Pilot Project

DESCRIPTION: A cooperative project to do a pilot test of the State General Soil Geographic (STATSGO) data base. The Soil Conservation Service (SCS) is providing digital line data and soil attributes for soil associations. The US Geological Survey (USGS) is processing the data to make interpretive maps and to test the data with other data layers from their National Digital Cartographic Information Center (NCIC) data base.

AGENCY NAME: Soil Conservation Service
Cartographic and GIS Division
US Department of Agriculture
P.O. Box 2890, Rm 6245-S

PROJECT NAME: Virginia Geographic Information System (VirGIS)

DESCRIPTION: Developed by the Agricultural Engineering Department, Virginia Tech, to assist in targeting Virginia's agricultural land with the greatest potential for delivering sediment to the nearest stream. The data base consists of grid cells referenced to the UTM coordinate system, and averaged over one hectare cells. Elevation is averaged over 4 hectare cells.

AGENCY NAME: Virginia Division of Soil and Water Conservation
203 Governor Street
Suite 206
Richmond, VA 23227

PROJECT NAME: Choptank River Pilot GIS

DESCRIPTION: A regressions model using GIS technology to relate land use changes with nutrient loadings and identify high priority non-point source pollution areas.

AGENCY NAME: US Fish and Wildlife Service
Annapolis Field Office
1825 Virginia Street
Annapolis, MD 21401

PROJECT NAME: Elizabeth River Pilot Project

DESCRIPTION: A cooperative project between the US Environmental Protection Agency and the US Geological Survey to demonstrate GIS technology to identify and assess toxic sources of pollution in the Elizabeth River at Norfolk Harbor. USGS transportation and hydrology data were digitized from EPA's Environmental Photo Interpretation Center aerial photography. For the first time, historic land use data is being used on a GIS to identify potential hazardous waste sites.

AGENCY NAME: US Geological Survey
Water Resources Division
3600 West Broad Street, Rm 606
Richmond, VA 23230

X. THE CHESAPEAKE BAY GIS WORKGROUP met for the first time on May 15. Our first order of business was to refine the information that will be published as the Chesapeake Bay GIS Atlas and kept updated on the CBP computer information network. The workshop defined the scope and format of the Atlas, starting from an initial project listing and eventually becoming a sort of GIS yellow pages. The ultimate product would provide a user interested in GIS data, with sources and caveats as to data quality and uses.

We also further outlined data needs for existing and anticipated GIS applications. Many of the groups involved have similar data needs. As these data sources are identified, we are finding additional participants for our workgroup.

Most important, the workshop participants began to discuss mechanisms to share existing GIS data and how to generate data in other formats. Our goal is to provide the technology and data to those in the basin that need it, and to do so for the least expenditure of time and money.

XI. THE FUTURE OF GIS TO CBP is lit with excitement by all involved. We feel that upper management is aware of GIS technology and its potential benefit to the Program through small, low-budget examples, and the mechanisms in place to make the most of any investment. We are confident that GIS will be an asset to the many other tools used to make science more of a part in the political decision-making process to protect Chesapeake Bay.

EVALUATION OF THE REDLINE STAGE

FARMINGTON DEMONSTRATION PROJECT

by

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Balkus, Carol, Farmington Resource Area
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DESCRIPTION

A. PURPOSE

The purpose of the Redline Phase of the Farmington Demonstration Project was to demonstrate in a field office environment the linkage of records, resources, and coordinates to improve land based decision making. The project assisted the Bureau in defining functional and system requirements for an interim Land Information System (LIS) and helped clarify functional and system requirements for a future LIS.

The Farmington Resource Area was chosen for the demonstration because of its large and diverse workload. The Bureau also believed Farmington would provide a field environment where more comprehensive potential Bureauwide applications could evolve. (Figure 1 shows the location and coverage of the Study Area.)

The Application for Permit to Drill (APD) was selected as the vehicle for the test because its requirements for processing data are similar to a number of other case processing functions in the Bureau.

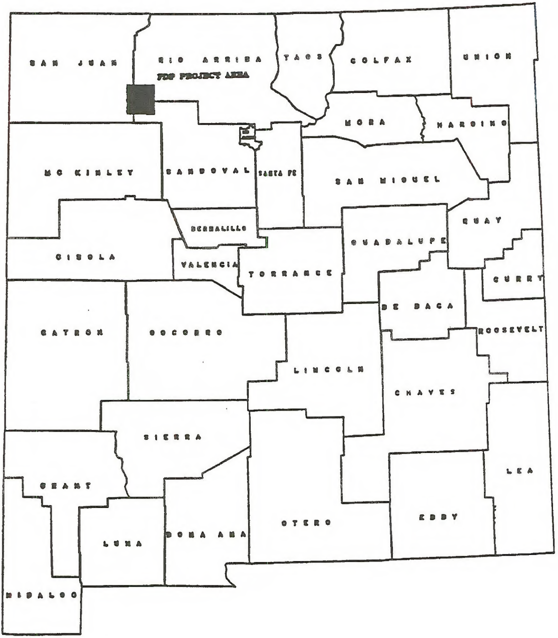


Figure 1 Location of the Farmington Project Area

B. SCOPE OF THE REDLINE

The Redline was conducted primarily by the New Mexico State Office (NMSO), Division of Operations, with assistance from the following:

- o Albuquerque District Office
- o Farmington Resource Area
- o Service Center (SC)
- o U.S. Department of the Interior, Geological Survey (USGS)

The NMSO utilized a limited number of highly skilled personnel for the demonstration project. Many offices in the Bureau, however, do not have personnel with the skills exhibited by the Division of Operations Staff for constructing GIS data bases. A thorough knowledge of the Automated Digitizing System and Map Overlay and Statistical System (ADS/MOSS) and Data General's (DG's) operating system and utilities, along with computer systems support staff, were required. Although preliminary efforts were made to prepare data and selected programs, most of the accomplishments were conducted over an 8-week period, from December 1986 through January 1987.

The Project primarily used existing NMSO hardware and software capabilities. An additional program was written to generate geographic coordinates for oil and gas wells from footage calls. Macros were also developed by using DG's Advanced Operating System (AOS), REV 7.2, to assist with data reformatting and to improve and simplify data processing.

The Redline effort followed three major steps:

- o Acquisition of Data: Data requirements were identified and requests were made to obtain information appropriate for the data base.
- o Data Base Construction: Data were reformatted and loaded onto the DG; the data base was constructed for a nine-township area.
- o Use of the System: Macros were developed and used to demonstrate tools available for processing an APD and for generating Master Title Plats (MTPs).

C. HARDWARE CONFIGURATION

Most of the work was done on the DG Model M600 computer at the NMSO. This system was used for constructing the data base and for processing all land information. Additional tasks, such as initial retrieval of Case Recordation and Status data, were performed on the Honeywell DPS8 at the SC.

D. SOFTWARE CONFIGURATION

Software consisted primarily of the following existing Geographic Information System (GIS) software packages and specialized macros written with the AOS:

- Automated Digitizing System (ADS)--Captures, displays, and edits mapped information in a vector/coordinate format.
- Map Overlay and Statistical System (MOSS)--Processes and displays mapped information in vector or raster formats.
- Map Analysis Package (MAP)--Processes and displays mapped information in a raster format.
- Public (land survey) Coordinate Computation System (PCCS)-- Computes geographic coordinates based on surveyed bearings and distances.

The following programs are conceptually part of the GIS packages but were written separately in FORTRAN 77 to expedite the transfer of software to Prime computers.

- Generate Geographic Well Location (GGWL)--Generates geographic coordinates for wells, based on legal descriptions (meridian, township, range, section plus footages).
- Interactive Generation of Geographic Well Location (INTGGWL)--Provides a user interface to capture legal descriptions of well locations.
- PCCS2ADS--Converts PCCS data to ADS and generates section lines for a township.
- Parcel Generator--Generates land parcels based on legal land descriptions and land net coordinates.
- PGFORMAT--Provides a capability to interactively create a file of legal land descriptions for Parcel Generator.

Systems operations and macro development were performed with DG's Command Line Interpreter (CLI) of AOS, Revision 7.2; Screen Editor (SED); SORT/MERGE; and Report Writer. Several macros were developed to set graphics terminal characteristics and to provide a simplified user interface; however, the macros were primarily used to assist in reformatting data.

ACQUISITION OF DATA

A. ACQUISITION PROCEDURES

1. Coordinate Data.

Coordinate data were available from three sources. Digitized and generated coordinates were collected at the NMSO, while computed coordinates from surveys were provided through the cooperative efforts of the New Mexico, Colorado, and Oregon State Office Cadastral Survey staffs. Coordinate data were....

- o Generated to produce generic rectangular coordinates (based on a standard township).
- o Digitized from USGS 7 1/2-minute quadrangles.
- o Computed based on satellite positioning and conventional survey methods.

2. Records Information.

- o Status data were requested from the Automated Land and Mineral Record System (ALMRS) Coordinator in the NMSO. Status was downloaded from the New Mexico ALMRS data base, reformatted at the SC, and delivered on tape.
- o Case Recordation data were requested of the ALMRS Project Office at the SC and delivered to the New Mexico State Office. Oil and gas leases were contracted from this data set.
- o Panel maps were requested in hardcopy (nondigital) format from the Albuquerque District Office. These maps portrayed the boundaries of Communitization Agreements (CAs), Unitized Agreements (UAs) with participating areas, and Known Geologic Structures (KGSs).

3. Resource Information.

- o A number of resource data themes were already available in digital format at the NMSO from Farmington's Resource Management Plan. Available themes included cultural sites, paleontology, mineral ownership, and wildlife habitats.

- o Resource maps were obtained from the Farmington Resource Area for digitizing. Since the original maps could not be released, the data were transcribed onto USGS 7 1/2-minute topographic maps for shipment. Map themes included roads, allotment boundaries, and range improvements.

- o The request for Petroleum Information, Inc. (PI) data was made to USGS, Division of Water Resources by the District Office, while acquisition of other themes through USGS was coordinated through the ALMRS Project Office. PI data were delivered to the NMSO and Digital Elevation Models (DEMs) were delivered to the SC for preprocessing but data were not used because of delivery schedules and time constraints. Transportation and hydrography data were not delivered. (Roads were digitized after nondelivery became evident.)

B. ISSUES, PROBLEMS, AND SOLUTIONS

The Redline experience showed that data acquisition deserves considerable attention in future projects. The delays, resulting from late delivery or nondelivery of data, placed serious time constraints on the project. In these cases, a third party was usually involved. While this may not have been the only reason for inadequate response, it almost certainly complicated communications.

C. RECOMMENDATIONS

Third-party arrangements for acquiring data should be avoided. Requests should be made in writing and contingency plans should be made to accommodate potential problems. Knowing early in the process that data will be late or unavailable can allow adequate time for rescheduling or making other arrangements to acquire the data. Every attempt should be made to establish and maintain direct communications with data sources and to work on potential problems early in the process. Thus, adequate time must be allowed to acquire data, especially if data must be obtained from other sources.

DATA BASE CONSTRUCTION

A. COORDINATE DATA

1. Description of Procedures.

Bearings and distances obtained from the resurvey field notes were entered into the PCCS program to produce a digital file of adjusted Universal Transverse Mercator (UTM) geographic coordinates for each township. This file, produced on the SC Honeywell DPS 8, was reformatted and transferred to the MOSS software on the DG M600. Several SORT/MERGE macros were written to correct record length and record delimiters as well as to make changes to octal format. (Figure 2 shows a sample file created with PCCS.)

400200	361641.0	1074039.5	6800.	10	30	259488.284017915.310
400240	361707.1	1074038.7	6800.	10	30	259530.874018719.280
400300	361733.2	1074038.7	6800.	10	30	259553.384019524.860
400340	361759.3	1074039.3	6800.	10	30	259561.094020327.340
400400	361825.3	1074039.9	6800.	10	30	259568.814021129.820
400440	361851.3	1074039.3	6800.	10	30	259604.204021931.770
400500	361917.4	1074038.8	6800.	10	30	259639.594022733.710
400540	361942.9	1074039.7	6800.	10	30	259638.334023520.890
400600	362008.4	1074040.6	6800.	10	30	259637.064024308.060
400640	362033.9	1074041.7	6800.	10	30	259632.724025094.080
400700	362100.7	1074042.8	6800.	10	30	259628.124025922.530
440100	361548.8	1074007.0	6800.	10	30	260254.064016282.710
440200	361641.0	1074007.3	6800.	10	30	260292.974017892.510
440300	361733.3	1074006.4	6800.	10	30	260358.444019503.040

Figure 2 Sample File Created with the PCCS Program

(UTMs appear in far right fields.)

The PCCS2ADS program was used to convert geographic coordinates to section boundaries into ADS line maps from which a township map of the Public Land Survey System (PLSS) was produced. Figure 3 shows a sample township output product. Coordinates not on a section boundary were converted to ADS as a symbol file. The ADS maps were then transferred by MOSS so they could be used as base maps for resource analysis. Figure 4 shows the flow of the data base construction process used in the project.

2. Problems, Issues, and Solutions.

The main problem was nonstandard data exchange formats. The PCCS file, transferred to the DG, was visually reviewed before PCCS2ADS was executed and some incompatibilities were corrected using SED. Specifically, record length was changed and carriage returns were added. When the file seemed correct to PCCS2ADS import specifications, the program was executed.

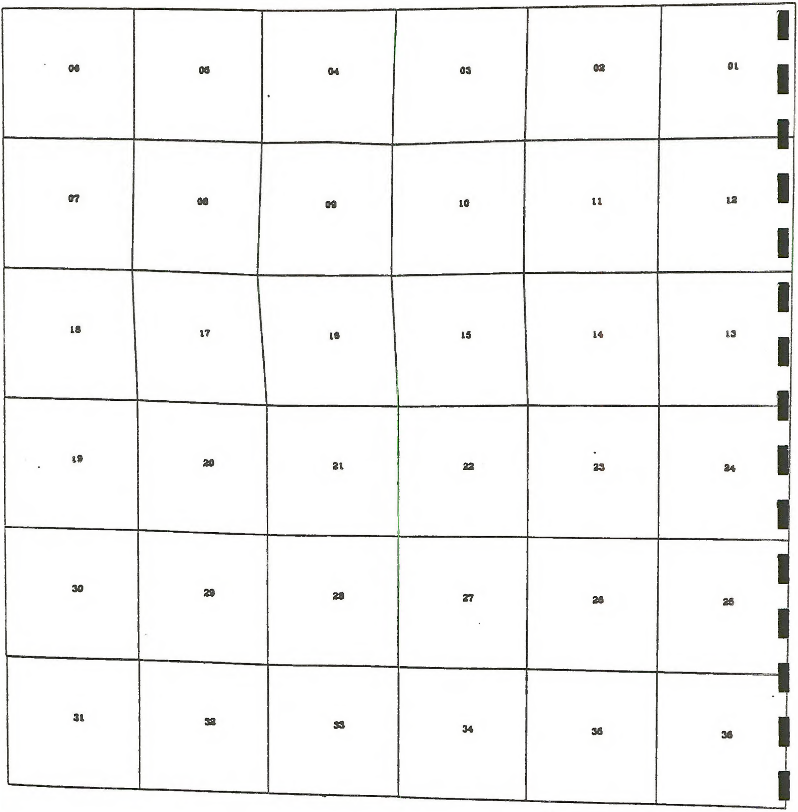


Figure 3 Product Generated after PCCS2ADS and CLOSEPOLY were executed (This product is a geographically referenced map of the section boundaries in a single map.)

COORDINATES DATA FLOW

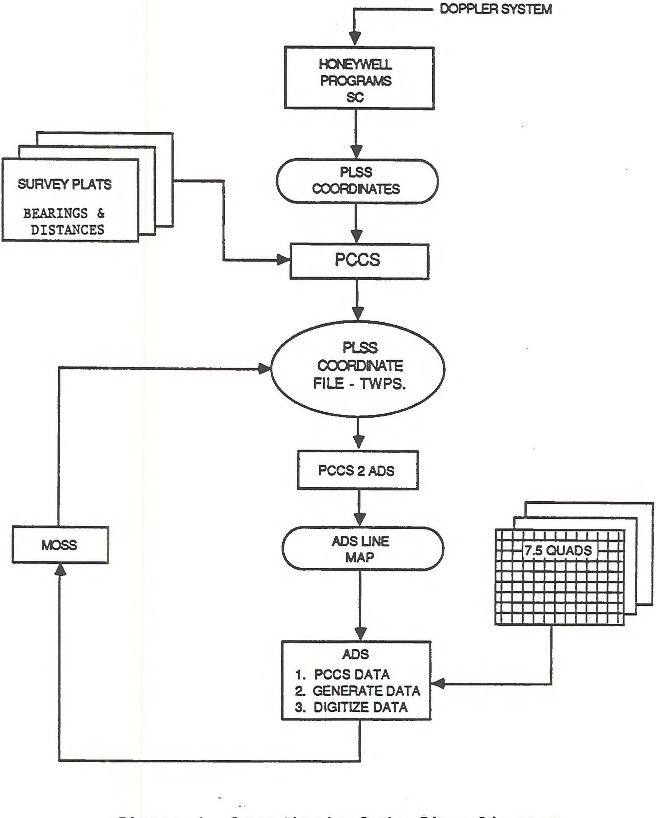


Figure 4 Coordinate Data Flow Diagram

NMSO had to write a macro to convert Honeywell ASCII to standard ASCII format before PCCS2ADS could be successfully executed.

The PCCS2ADS handles only standard townships in UTM coordinates and generates section lines based on the coordinate coding method in PCCS. Thus, some section boundaries may have to be edited in ADS. Since PCC2ADS cannot process townships containing meander lines or metes and bounds, this information must be digitized.

For those coordinates used to generate the graphic in Figure 3, the associated reliability factors resulting from the transfer are from 10 to 30 feet. This means that coordinate or map point represents an on-the-ground accuracy of from 10 to 30 feet of its actual location. PCCS2ADS maintains the accuracy of the coordinates generated with PCCS.

3. Recommendations.

a. To avoid miscommunication of tape specifications including record length and carriage returns, written statements with proper tape specifications are recommended.

b. Writing macros to accommodate nonstandard ASCII format is time-consuming and difficult for the average user. These kinds of macros or similar programs should be automatically executed during data conversion and remain invisible to the user.

c. PCCS2ADS should be modified to accommodate townships containing meanders and metes and bounds to increase its potential for other applications.

d. Information contained in the geographic coordinate data base should meet most of the needs of private and public users. In addition, the user interface and indexing system (i.e., the ability to select information by township, range, section, county, and state) should be compatible with commonly used conventions and data formats. Thus, file formats and processing procedures should be standardized and documented.

B. RECORDS DATA

1. Description of Procedures.

Parcel Generator was used to generate digital maps from alphanumeric legal descriptions and land net coordinates. The record input data format required for Parcel Generator was modeled after Legal Land Description (LLD) Status collection standards. These formats include status types L, 9, A, and 3. Other LLD/Status data formats are flagged as errors by the program.

This Parcel Generator allowed records to be processed with the township grid data in ADS to generate geographically referenced maps. These maps showed land ownership, oil and gas leases, KGS areas, UAs, CAs, and well locations through various line types, color, and shading. The Parcel Generator program was used to subdivide sections, using only coordinates falling on section boundaries. Although interior section coordinates were transferred to ADS as a symbol file, they could not be used. The maps can be stored, accessed, and plotted by Public Land Record users with very little computer experience.

The format for collecting status is defined in the Status Coding Handbook, using Application 2002 of the Data Element Dictionary. Figure 5 shows an example of one status data format. Oil and gas lease information from Case Recordation was provided as "raw" data, which required macro programs to sort and reformat. Figure 6 shows an example of reformatted Case Recordation data. The KGS, CA, and UA legal descriptions were interpreted from the hardcopy panel maps, coded and entered in a status format. PG Format was used to enter the data. All records data were processed with Parcel Generator to produce graphics of surface ownership, oil and gas leases, KGS, CAs, and UAs. Figures 7 and 8 show patented lands and oil and gas lease boundaries, respectively, which were computed with Parcel Generator. Figure 9 displays the data flow for records information.

2. Problems, Issues, and Solutions.

a. Standardization

A major problem encountered with records data was the lack of standards for collecting and coding. Surface ownership and oil and gas lease information had been collected in various formats, independent of the project. Additionally, the size of fields varied for oil and gas lease information, requiring it to be sorted and reformatted.

b. Time

Oil and gas lease information was received 8 weeks after requested, partially because programs had to be developed to retrieve only oil and gas data from the more extensive Case Recordation files at the SC. The development of programs for sorting and retrieving data, and the subsequent processing of the data at the NMSO to standardize exchange formats, required a considerable amount of time. Many of the sorting and retrieval requirements could have been handled more effectively with an Relational Data Base Management System (RDBMS).

c. Parcel Generator Limitations

The Parcel Generator software could not interpret oil and gas lease data described in normal legal conventions for distance and bearings, offset measurements, or descriptive free formats. While free-format descriptions will require entering data manually, distance and bearings and offset measurement capabilities could realistically be developed for the software.

The existing Parcel Generator software also has difficulties dissolving duplicate lines where legal descriptions for the same lands are given more than once, resulting in additional editing through ADS. If not edited, overlapped areas become separate polygons in ADS. Additionally, the program does not use coordinates interior to the section boundaries.

The Parcel Generator cannot produce maps from record data unless coordinate locations fall on a section boundary. Coordinates interior to the section are computed based on standard rules for subdividing by aliquot part and regular lots.

011900NMSF	061156	1230240N0060W005L		1,2,7,8;
011910NMSF	061156	1230240N0060W006A	X	
011920NMSF	061870	1230230N0070W003A	XX XX	
011930NMSF	061870	1230230N0070W003L		1-4;
011940NMSF	061870	2251104PA1081211 02061936942900		
011960NMSF	062968	1230230N0060W0249		
011970NMSF	062968	2251104PA1077554 08131935942900		
011990NMSF	062969	1230230N0060W0259		
012000NMSF	062969	1230230N0060W0259		
012010NMSF	062969	2251104PA1076353 06181935942900		
012030NMSF	064348	1230220N0060W0019		
012040NMSF	064348	2251104PA1067534 12281933942900		
012060NMSF	066677	1230230N0060W022A	XXXXXX	

Figure 5 Example of Status Coding and Formats

9NMSF	0078925	2	PASF78925	
4NMSF	0078957	1230240N0060W004L		1-4;
4NMSF	0078957	1230240N0060W005L		1-4;
4NMSF	0078957	1230240N0060W003L		1-4;
4NMSF	0078957	1230240N0060W006L		1-4;
9NMSF	0078957	2	PASF78957	
4NMSF	0078959	1230240N0070W007L		3,4;
4NMSF	0078959	1230240N0070W0073		SE,E2SW;
9NMSF	0078959	2	PASF78959	
4NMSF	0078974	1230240N0070W7073		E2NW,NE;REL
4NMSF	0078974	1230240N0070W707L		1,2;REL
4NMSF	0078974	1230240N0070W0223		S2NW,N2SW;
9NMSF	0078974	2	PASF78974	
4NMSF	0079086	1230240N0060W0143		N2;
4NMSF	0079086	1230240N0060W018L		1-2;

Figure 6 Example of Case Recordation File reformatted to Status Types L, S, A, and 3 Data Formats

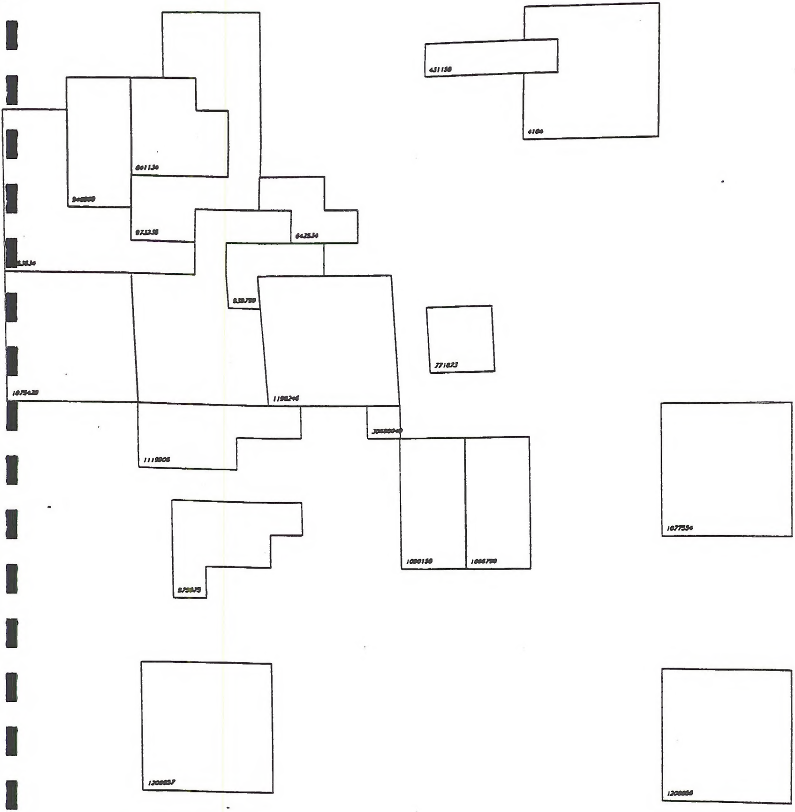


Figure 7 Patented Lands Map depicting the Computed Graphic, produced with Parcel Generator

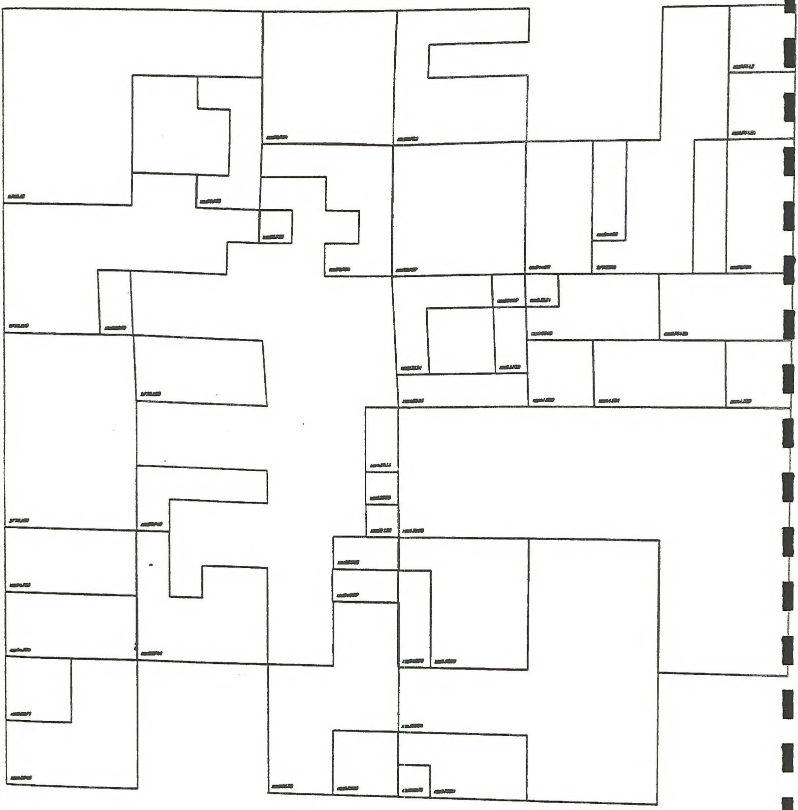


Figure 8 Oil and Gas Lease Boundary Map

depicting Computed Graphic, produced with the Parcel Generator

RECORDS DATA FLOW

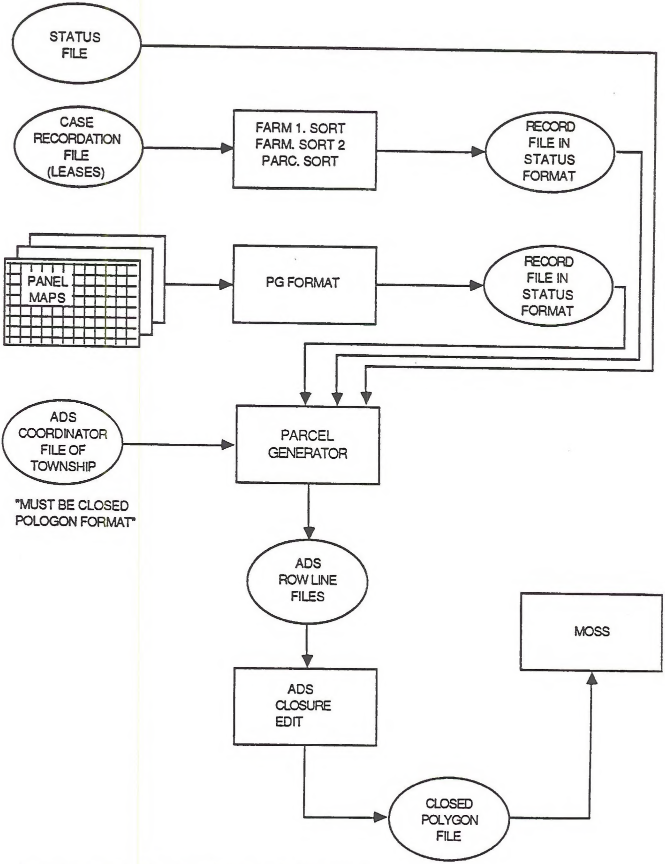


Figure 9 Data Flow for Records Information

Parcel Generator can best be used with entire townships; but the user may specify individual sections. If an entire township is not included on a USGS quad, data in the sections that fall on quadrangle boundaries must be captured by digitizing in ADS. However, a program called EXTRACT has been developed that retrieves the appropriate portions of a township from multiple quads and merges them into a single map. The resulting township can be effectively used by the Parcel Generator.

d. Updating

An operational concern is keeping Case Recordation data current. Once the case records were processed to produce graphics, using data from the Honeywell DPS 8, the dynamics of the case records were lost. The ability to update alphanumeric case records and graphics must be recognized as a vital link in the system. Case records must be continually updated to reflect actions occurring on the leases via State adjudication decisions because these actions affect BLM field decisions on post-lease activity.

3. Recommendations.

The conversion of land record information, such as oil and gas lease boundaries, from legal descriptions in the case recordation files to geographic locations, was a significant component of the Redline. This conversion effort utilized existing oil and gas lease information from Case Recordation along with the Parcel Generator software, reducing the need for digitizing and demonstrating the capability to merge records data with resource data.

The Parcel Generator software is based on standard aliquot part surveying conventions and will probably be effective in 80 percent of the applications where legal descriptions and land net follow these conventions. The remaining 20 percent, representing nonstandard surveying situations, will require editing or digitizing. Parcel Generator should be used with the most accurate land net data available and should be enhanced to use coordinates interior to section boundaries to make full use of survey information in generating township grid.

With the capability to convert legal descriptions to geographic locations, the Parcel Generator can potentially be used in other applications, such as providing check plots to assure the accuracy of legal land records, automating MTPs, and improving graphic accuracy by incorporating current survey information from PCCS.

Because data were collected in a nonstandard format, sorting and reformatting were major problems. The data provided from Case Recordation should be standardized by developing a sort/reformat program to improve consistency and increase immediate utility. This requires establishment and adherence to Bureauwide data standards. The availability could also be significantly improved by allowing the State Offices with current GIS configuration to access and copy files, rather than only obtain reports.

Data management and manipulation capabilities could be improved by adopting an RDBMS that allows the user to select and use combinations of data from a single file. This capability could also be used to maintain and update case recordation files, keeping data current and valid.

C. RESOURCE DATA

1. Description of Procedures.

The APD checklist provided guidance for entering resource themes into the data base. Resource themes included threatened and endangered species, allotment boundaries, hydrography, roads, paleontological sites, wildlife habitats, and range improvements. Some of these data themes were drafted on maps in the Farmington Resource Area Office; however, some inventories, such as range improvements and cultural surveys remained incomplete. These maps were duplicated and copies were sent to the State Office for digitizing.

The PI well data, were furnished on magnetic tape in a flat-file text format. The file was loaded and the DG SORT/MERGE utility was used to search for and identify missing records. The locations of wells in the file were referenced by footage calls from section lines as well as by actual geographic coordinates.

A program called GGWL computed additional geographic coordinates for wells by referring to the ADS map of the PLSS grid and applying footage calls from the PI file. Before the data could be processed with GGWL, however, the file had to be reformatted. The attributes for each well, other than a well identification number, were removed and placed in a separate text file using the SORT/MERGE utility, after which the GGWL program was executed. Coordinates for 300 wells in the region were computed in about an hour producing an ADS point map for transfer to MOSS.

The file of remaining well attributes, created in the reformatting procedure, was used to create a multiple-attribute file in MOSS allowing map items to be selected based on boolean criteria. Figure 10 displays data flow for resource information.

2. Problems, Issues, and Solutions.

Both footage calls for well locations, geographic coordinates were available from PI; however, locations for the same wells varied. To assess the quality of existing and computed coordinates, a single map was created showing the well locations from both sources. (See Figure 11 for location data.) The resulting map was compared to photogrammetrically derived well locations and PLSS corner positions. The coordinates computed using GGWL proved to be significantly more accurate.

The problem of nonstandard ASCII formats again was flagged again in this process. The PI files had to be manipulated to make them DG/ASCII-compatible. The solutions for this problem were the same as those cited in the earlier descriptions of incompatible ASCII formats.

The data had to be reformatted before the GGWL program could be applied. Again, file manipulation (using SORT/MERGE) was required before processing could proceed. Unfortunately, this required manipulation can be unique to each file, limiting the application of the SORT/MERGE routines to be executed in a macro mode.

RESOURCES DATA FLOW

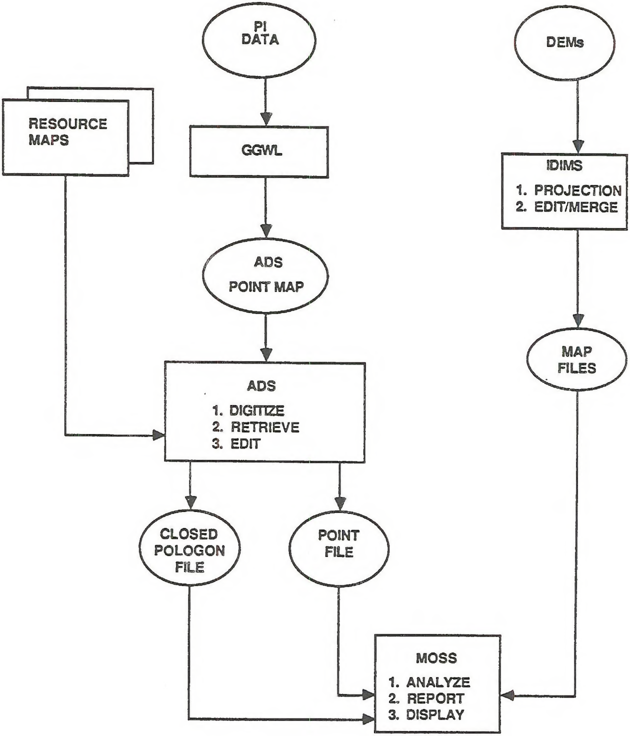


Figure 10 DataFlow for Resource Information

05579	07	24	N	06	W	1733	N	1147	E	1
05580	09	24	N	06	W	1850	N	1850	E	1
05581	09	24	N	06	W	1750	N	1650	W	1
05583	08	24	N	06	W	1750	N	1750	E	1
05587	08	24	N	06	W	1750	N	890	W	1
05588	09	24	N	06	W	1750	N	790	W	1
05590	08	24	N	07	W	1980	N	1980	W	1
05591	10	24	N	06	W	1650	N	990	W	1
05602	08	24	N	06	W	1090	N	1650	E	1
05604	11	24	N	06	W	1115	N	1560	W	1
05605	10	24	N	07	W	990	N	1000	E	1
05607	10	24	N	07	W					1
05609	12	24	N	06	W	965	N	1840	W	1
05620	06	24	N	06	W	840	S	840	W	1
05630	05	24	N	06	W	890	S	990	E	1
05631	03	24	N	06	W	990	S	1650	E	1
05632	05	24	N	06	W	1100	S	1650	W	1
05634	02	24	N	06	W	990	S	1190	E	1
05636	01	24	N	06	W	990	S	1750	E	1
05638	03	24	N	07	W	1650	S	1650	W	1
05641	01	24	N	06	W	1673	S	1840	W	1
05642	02	24	N	06	W	1850	S	1750	W	1
05651	01	24	N	06	W	2175	N	1850	E	1
05653	03	24	N	06	W	1650	N	1090	E	1
05654	04	24	N	06	W	1672	N	1750	W	1
05655	03	24	N	07	W	1650	N	1650	E	1
05661	02	24	N	06	W	1494	N	1050	W	1
05666	02	24	N	07	W	1190	N	990	W	1
05667	02	24	N	06	W	1650	N	990	E	1
05670	04	24	N	06	W	1190	N	1500	E	1
05672	01	24	N	07	W	990	N	790	E	1
05673	01	24	N	06	W	1600	N	1550	E	1
05674	02	24	N	07	W	990	N	990	E	1
05675	01	24	N	06	W	1190	N	990	W	1
05676	04	24	N	07	W	990	N	790	E	1
05677	03	24	N	06	W	990	N	990	W	1
05679	01	24	N	06	W	990	N	990	W	1
05680	02	24	N	06	W	704	N	1870	E	1
05681	02	24	N	06	W					1
20018	04	23	N	07	W	1830	S	1700	E	1
20048.	03	23	N	07	W	1650	S	700	W	1
20110	11	24	N	07	W	1850	N	790	W	1
20148	18	24	N	07	W	990	S	1650	W	1
20231	02	24	N	07	W	1050	S	990	W	1
20245	30	24	N	07	W	990	S	990	E	1
20269	11	24	N	07	W	1850	S	1700	W	1
20282	01	24	N	07	W	1650	S	1650	E	1
20282	01	24	N	07	W	1650	S	1650	E	1
20443	22	24	N	06	W	990	N	990	W	1

Figure 11 PI Legals for Wells

The PI data had a number of missing records that required "dummy" records to be inserted, again requiring manual manipulation. The GGWL program should be modified to handle PI input file record problems.

3. Recommendations.

The ASCII standard provided on the PI tape and the DG ASCII standard were not compatible. The adoption and use of standard ASCII formats would eliminate or significantly reduce the problem of reformatting.

The GGWL program cannot handle PI files with missing records. The records must be manually inserted before the program can be run. The GGWL program should be modified to accommodate missing records.

USER VIEWPOINT

A. CAPABILITIES

Using survey methods and PCCS has significant advantages over digitizing methods because of improved accuracy of coordinate locations and quality control checks for survey data. The digitizing method requires significantly less capital investment to collect information, but potential data inaccuracies could lead eventually to significant costs related to lawsuits or loss of royalties.

Macros were written to simplify the user interface for processing data. These macros provided the users with a set of menus from which a number of options could be selected to perform specific tasks. Although GIS programs or commands were used, they required no GIS training to execute.

The Tektronix 4111 graphics terminal provided good facilities for examining, displaying, and working with geographic data. This terminal is much improved over the equipment currently being used by other Bureau field offices.

B. ISSUES AND PROBLEMS

Not enough time was allowed for developing the macros or programs required to manipulate the alphanumeric data base. These programs, however, would have required a significant effort to develop. An RDBMS would have satisfied most of these requirements and would have reduced the time needed to handle all information.

Macros demonstrated the need for a more simplified user-machine interface if LIS capabilities are to be implemented in field offices. Additionally, Resource Area personnel did express the need for more flexibility in using the system, a capability that the macros did not provide. The macros were written in the language of a nonstandard operating system and thus can only be used on DG computers that execute AOS.

The quality of data was cited as a major, potential problem. Some of the data were inaccurate, inconsistent, or simply not available for this project. Geographic locations of wells proved to be inconsistent when retrieved directly from the latitude/longitude coordinates and computed than legal descriptions. Figure 12 shows the locational differences of wells that were common throughout the PI data file. (Note that latitude/longitude locations tend to be systematically displaced to the southwest.) By comparing these locations with well maps derived from photogrammetric placement, the coordinates generated from legal descriptions (footage calls from the section line) proved to be more accurate. The accuracy of these locations, however, resulted from highly accurate land surveys throughout the study area. This may not be the case in other study areas. Additionally, not all the wells had legal descriptions, creating an incomplete locational data base when only legal descriptions were used.

Data were also a concern when plotting the maps derived from Case Recordation legal descriptions, with one active lease was not available in the data base. Resource Area personnel emphasized the need to have a complete data base that is accurate and up-to-date.

Locations of section boundaries varied according to source. The locations of digitized coordinates and coordinates computed with PCCS compared favorably for most of the study area, but isolated cases revealed significant differences. Figure 13 shows an example of locational differences between the two sources in T22N, R6W. The coordinates produced with PCCS were more accurate than digitized coordinates, given their original sources and systematic errors propagated through the digitizing process. The generic township coordinates were less accurate and were not compared, but proved useful for testing software and producing sample products.

Additionally, USGS 7 1/2-minute quads seldom portray the location of any coordinates in the land net, other than section corners. Survey data include all coordinates that affect the location of section boundaries. Therefore, section boundaries that change direction at a quarter corner are seldom captured in the process of digitizing, but are accounted for with PCCS. Figure 14 displays the kinds of differences that could result from similar situations.

C. RECOMMENDATIONS

Since the capabilities demonstrated and used as part of this demonstration are, for the most part, available on existing MOSS/ADS-based GIS systems in the Bureau, the Bureau should continue to use these systems to assist with accomplishing field tasks. Macros demonstrated the potential for improved user-machine interface of current GIS capabilities. However, the Bureau should not pursue the development of additional macros on DG equipment. The Tektronix terminal greatly improved the user's ability to examine and display graphic data and enhanced the user interface to the system. Existing graphics terminals currently being used for GIS should be examined for replacement, since many issues, such as the amount of time required to plot maps, can more easily be addressed by hardware than software.

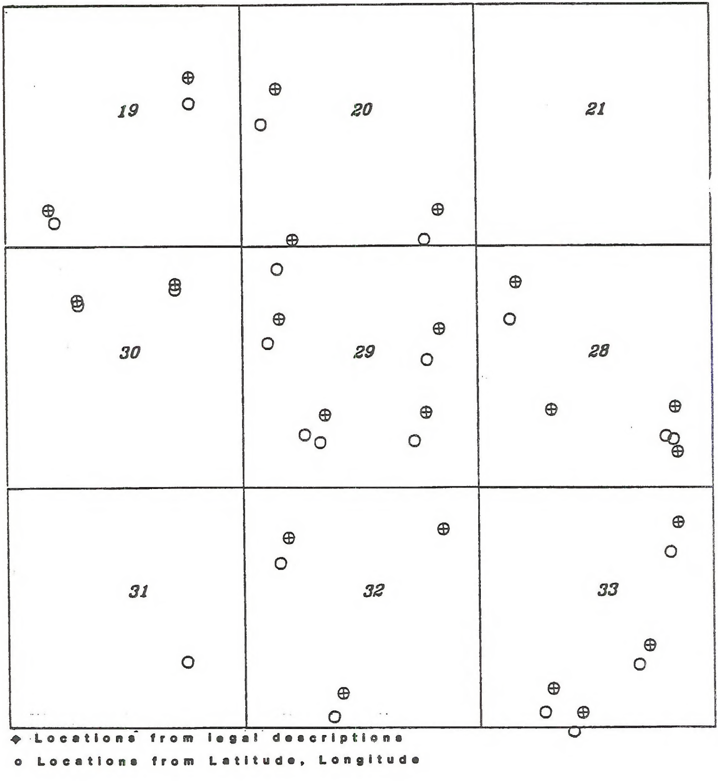


Figure 12 Example of Locational Variances on PI Data

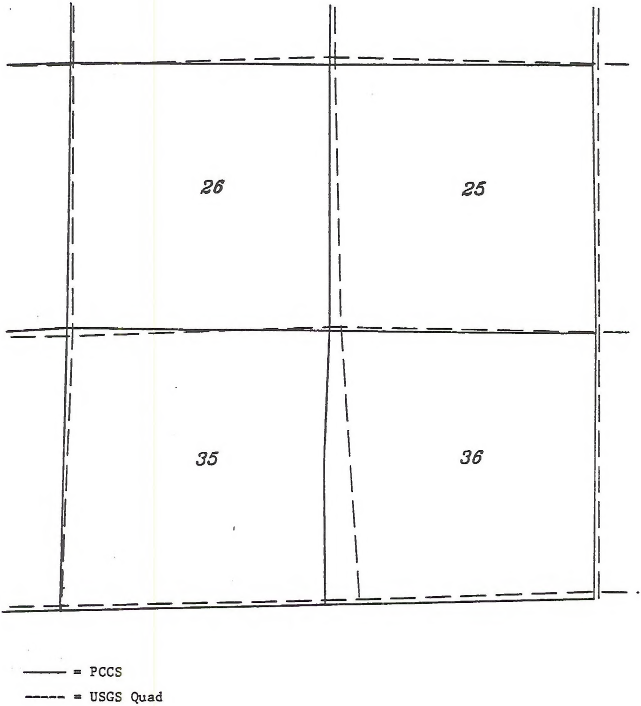
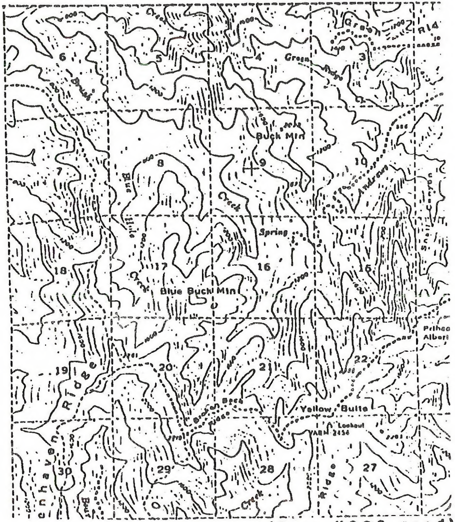


Figure 13 Locational Differences in Coordinates computed with PCCS and Digitized from a 7 1/2 minute quad



(from USGS quad)

(from PCCS)

Figure 14 Examples of Locational Differences between Coordinate Sources

(scales differ)

Data and the management of data should also be addressed. Attempts should be made to improve the quality of existing data and to standardize coding, accuracy, and transfer procedures. Serious consideration needs to be given to PI data and to Case Recordation. Capabilities for updating and quality control were specified as needed improvements. To enhance the capability, the Bureau should examine the potential interim applications of an RDBMS.

CONCLUSION

This project not only identified major problem areas for implementing LIS Bureauwide but demonstrated the potential benefits of such a system. All of the information provided as a result of this project will help the Bureau move toward full implementation of LIS in the 1990s.

Because the demonstrated capabilities did not include an RDBMS, the system had limited flexibility in analyzing alphanumeric data. Much of the data used for analysis, such as resource values or case data, was in an alphanumeric format. Currently, data must be stored in attribute files which are more cumbersome to use. Without an RDBMS, along with a Data Base Administrator, sort and retrieval of this data proved time-consuming.

Perhaps the most significant problems associated with implementing LIS center around data standards and data quality/availability. Eight of the 10 months spent on the project were devoted to identifying data requirements and converting the data files to a standard format. Additionally, only a few BLM offices have all the ALMRS-GIS data required for effective decision making based on LIS products. More importantly, each office would need to convert much of its data to a standard format, which would require a significant effort.

The Redline Phase of the Farmington Project demonstrates the benefits of automation. One comparison was made between the performance of the project and the performance of the Bureau's present digitizing system. Capabilities used in the project required 90 percent less time to capture data themes than the present digitizing system. This efficiency is gained however only if data exists in a standard format.

The project identified and documented the need for an improved user-machine interface. The benefits of a simplified user interface were also demonstrated along with data as the major criteria for BLM field acceptance.

With the capabilities demonstrated in this project, the Bureau can begin to develop a linked data base containing record and resource information that tie to positions on the earth in an automated manner. Since digitizing is avoided for records data, significant amounts of time and money are saved in creating and maintaining the data base. The Bureauwide applicability of a system that allows for the efficient use of heterogenous, but spatially related data are readily apparent. A system that gives quicker, more accurate analyses would allow the resource specialists more time in the field, resulting in more effective management of public lands.

THE DEVELOPMENT OF AN ARC NODE OVERLAY PROCESSOR FOR AMS

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A B S T R A C T

This paper describes the implementation of an enhancement to AMS that allows subsetting and overlaying of polygons and displaying the results. The capabilities, user interface, algorithms, and program structure of the implementation are discussed, along with problems encountered in interfacing to existing code and data structures. Also described are the software engineering principles and strategies used in the design and implementation of this system.

I N T R O D U C T I O N

This paper describes the design and implementation of an arc node overlay subsystem of AMS that is being developed by DBA Systems, Inc. for the U.S. Army Engineer and Topographic Laboratories (USAETL) at Fort Belvoir, Virginia. DBA is currently supporting UNIX and VMS versions of AMS, MOSS, and MAPS for USAETL, and has been requested to develop overlay capabilities in AMS. The target system was originally an HP 9030 minicomputer running UNIX, however, the project was subsequently redirected to a VAX/750 running the VMS operating system and eventually will be ported to a Micro VAX II.

In general, an overlay processor combines two or more maps of the same geographic area that represent different categories or themes of surface features. For example, a map of the soil of a particular region may be combined with a map of the flood potential of the same region to find areas subject to soil erosion. An overlay processor performs set operations to determine the union, intersection or difference of features depicted on two or more maps separates or overlays. Figures 1, 2, and 3 show examples of each operation.

Currently, the MAPS portion of the MOSS family allows overlay of raster data, and the MOSS program supports the overlay of vector polygon data. The primary motivation for the new overlay processor is to remove the limitations on the size of the overlays that can be performed with the existing MOSS software. In addition, the overlay algorithm used in MOSS is relatively inefficient with respect to processing time. This can be shown by the following proportion:

$$T \propto N^2$$

where T is time
and N is the number
of lines segments
to be compared.

The new overlay processor uses a more sophisticated algorithm which should improve performance (Guevara 1986). Processing time for the new AMS overlay processor can be represented by:

$$T \propto N \log N$$

USAETL also determined that output to an arc node format was more convenient than the polygon format of the data in MOSS. Thus, the new program should be a part of AMS, where the data is already in an arc node format.

C A P A B I L I T I E S

A view of the master menu provides a good starting point for a discussion of the capabilities required by USAETL. (See Figure 4)

The "working defaults" for the current session are shown at the top of the screen. This information is saved between sessions, and may be updated by choosing one of the menu options 5 through 8. Option 2, allows a user to select a set of themes as candidates for overlay. A user may also work with a subset of the attributes in a theme by selecting a set of attributes or excluding a set of attributes.

Option 3 allows a user to enter an overlay expression using any of the themes selected under option 2, and any of the three operators. A typical overlay expression would be

A - (B / C)

which translates to "find all of the area containing attributes from map A but not containing any of the area covered by B or C".

Option 4, allows the user to display the job file after the overlay has been performed and to selectively display polygons with certain attributes. The user may also point to a displayed polygon with the cursor and obtain the attributes of that polygon.

A L G O R I T H M S

Two papers that provide surveys of algorithms in current use in GIS, Aronson (1982) and Guevara (1984), were reviewed during the design phase of the project. Among the algorithms described are the ones in use by ANOTB, OVER, WHIRLPOOL, and MOSS. The algorithm in use in the WHIRLPOOL system is the only one that gives a theoretical performance of N Log N rather than an N squared performance. Thus, this algorithm was the obvious choice for our system.

The heart of the algorithm is to find the lines of the two maps that intersect. The WHIRLPOOL algorithms looks for intersections of chains of line segments and then does an operation similar to a binary search to look for the intersection of lines. The implementation developed by DBA in the new system looks for the intersection of line segments directly. This simplifies the coding considerably and makes the line intersection algorithm relatively

AMS ARCNODE OVERLAY PROCESSING

CURRENT DEFAULTS

PROJECT:	NEWJ	
GEOUNIT CENTER:	39,27,38	-74,32,30
WORKING BOUNDARY:		
NE CORNER:	41,00,16	-73,00,00
SW CORNER:	37,55,00	-76,05,00

OVERLAY PROCESSING MENU

1.0 EXIT

2.0 SELECT THEMES TO OVERLAY

3.0 DO OVERLAYS

4.0 DISPLAY / ANALYSIS

5.0 CHANGE PROJECT

6.0 CHANGE GEOUNIT

7.0 CHANGE WORKING BOUNDARY (INPUT COORDINATES)

8.0 CHANGE WORKING BOUNDARY (SELECT WITH CURSOR)

ENTER MENU SELECTION [1] : 10

Enter a number between 1 and 8 (Press RETURN to re-enter) :_

Figure 4. Master Menu

efficient. After the line intersections are found, a pass is made through the polygons to concatenate the attributes of the lines of polygons involved in intersections. Another pass is made through the polygons to look for islands and to make further adjustments to the attributes. Finally the resultant maps are combined and written to an AMS job file.

The line intersection algorithm can be understood intuitively by imagining the two maps to be side by side as shown in Figure 5. A horizontal bar sweeps up through the two maps. Whenever the bar crosses the bottom of a line, that line is added to a list to be tested for intersection. Whenever the bar crosses the top of a line, that line is removed from the list being compared for intersections. This way we do not have to test every line against every other line for a possible intersection, but only those lines in a narrow band moving up the map. In the above example lines 1, 7, and A have all been processed. As the bar continues to move upward, line C will next be added to the "Short List" on the right and check against lines 2 and 6 for intersection.

D E S I G N   C O N S I D E R A T I O N S

The goals of the design were to produce a high performance system that can be easily maintained and ported to other computers and operating systems with minimal effort. The ability to port to another computer has already been useful because of the redirection of the project from implementation on the HP-UNIX system to implementation on a VAX/VMS system.

Within the last few years the language C has become available in a standard form on most computers and has thus become an alternative to FORTRAN for scientific software systems. The tools provided by C for isolation of the parameters that control the size of the problem that can be solved, and C constructs that assist in writing structured, modular code made it the language of choice for the overlay processor. A more technical discussion of the advantages of C is found in the section on implementation details.

U S E R   I N T E R F A C E

The new interface implemented with this system is similar to the old in that options are presented in menu format and the user responds to prompts. Also the user may select a default option appearing within brackets on the prompt line by pressing return. However, the introduction of a few simple screen handling primitives and the addition of a few conventions have improved the appearance. The master menu displayed in figure 4 illustrates the conventions adopted. The display shows the master menu after the user has selected option "10", which is invalid.

The screen handling routines divide the screen into four parts. The top part of the screen is a display area that shows current selections or other system states. The next section of the screen is used for menus or detailed instructions. The second line from the bottom is reserved for messages (such as progress reports) and prompts. The bottom line on the screen is reserved for error messages.

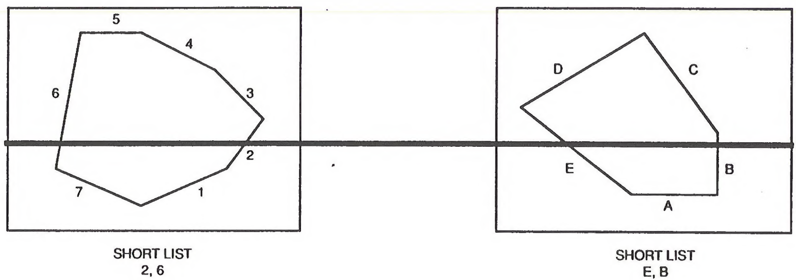

Figure 5. Example of Side-by-Side Maps Showing Line Intersection Algorithm

DESIGN PHILOSOPHY

For years, system designers have been using a top down approach to handle the complexity of large programming systems. In this approach a program is broken down into a small number of steps. Then the steps are further broken down, until the lowest set of steps can be easily implemented in a programming language. Each step then becomes a subroutine in the implementation. A deficiency of this design technique is that it ignores the role of the data in the system. Thus, the data passed to step 3 from step 1 and step 2, for example, may consist of a large number of items which involve complicated intersections among themselves. Object Oriented design grew out of a need to manage the complexity of data.

Object Oriented Programming ideas first appeared in the language SIMULA and reached a full implementation in Smalltalk. An "object" is a data entity and the operations that can be performed on that entity. A program invokes an operation of an object by sending an object a "message". A programmer can define "classes" of objects, and subclasses can be defined that "inherit" attributes and methods of the superclass.

In a strict sense, newer languages such as Ada , and Modula-2 are not object oriented languages in the Smalltalk style. However, the definition of Object Oriented Programming has evolved to mean a design and implementation methodology that uses the concept of objects as a means of handling the complexity of large programming systems. In this methodology a program module represents an object or class of objects. All knowledge of the internal structure of the object's data should be limited to this module. This technique is often called "enforcing the abstraction". Thus, in object oriented design, data moves through the system in large "chunks" whose internal structure can not be manipulated except in well defined ways by an isolated group of procedures.

The high level objects chosen for the implementation of this project include "Projects", "Geounits", "Themes", "Attributes", and "Maps". The operations on these objects include "Selection", "Graphing", and "Overlaying".

The programming language in which a designer thinks has a powerful influence on the design of a software system. Thus, a language that allows and, as much as possible, enforces good software engineering principals should be used in the design. For this reason the detailed design of the Overlay System is in the form of Modula-2 used as a program design language (PDL). A PDL gives a precise algorithmic description of a system that is easy to convert into code.

Using Modula-2 as a PDL provides a number of advantages over writing the code directly in an older language. First, Modula-2 has a simple, easy to read syntax and like most modern programming languages, Modula-2 provides powerful data type definition facilities and control structures that allow structured programming. Modula-2 provides for long variable names. Thus, variable names can be self descriptive. Procedures can be grouped into modules, with each module having its own local data typed and procedures. This grouping can make the logical structure of a system easier to understand, and provides for implementing information hiding. Modula-2 also provides for separating a module's definition part from its implementation part. This makes the

difference between the purpose of a module and its implementation very clear, thus providing a programmer with information on what parts of a module can be modified without affecting other parts of the system. In addition, Modula-2 requires that a module using a procedure or data type defined in a lower level module must implicitly import the procedure or data type with an "IMPORT" statement. This provides excellent documentation of the resources used by a module. When complied, Modula-2 provides strong type checking across procedure interfaces. This checking of the consistency of the system can detect many logic errors that might otherwise escape detection.

IMPLEMENTATION DETAILS

When integrating a software subsystem into a larger system, a number of decisions must be made. For example: What parts of the existing code can be re-used? How much compatibility with the existing user interface should be maintained? Should the new code follow the style and structure of the old?

A number of problems were seen in re-using or significantly modifying existing code. While much of the code is very good, large portions of the code do not adhere to such common software engineering principles as structured programming, or indentation of the code in loops to reflect structure. One of the biggest problems with using existing modules is the extensive use of FORTRAN common data variable which hide (or destroy) any hierarchial structure of the data flow and makes use of a single module from the system difficult. Although the code is compatible with FORTRAN 77, most of the code uses the FORTRAN 66 style, so that IF-THEN-ELSE constructs, parameter statements, and CHARACTER variables are seldom used.

The conclusion reached in the design of this project was that it was much easier and less expensive to write the entire overlay system from scratch than to use any existing code. The overlay program is initiated from the master AMS menu, operates on the same data files, uses the same graphics libraries, and has a similar user interface, but in every other way is a new system.

The sophisticated algorithms needed for efficient implementation of arc node overlay required correspondingly sophisticated data and program structures. Thus, the language C was chosen over FORTRAN as the implementation language, primarily because of FORTRAN's lack of data structures, and inability to handle recursion, which is used in some of the algorithms. The wider variety of control structures available in C also assist in using structured programming techniques. Another advantage is that all of the Modula-2 used in the design can be directly translated into C constructs.

C provides an "#include" statement that includes text from another file before compilation. This feature allows us to emulate the import of data types available in Modula-2 and used in the PDL. All data type definitions used in more than one file are defined in a separate "h" file and included in the source code files that need them. This means that these definitions appear in only one place, which simplifies changing them and eliminates the possibilities of different definitions in different programs.

In order to make the system more protable, the operating system and device dependent features were isolated into three main modules. The procedures to create directory/file names, get system error messages, and do any system

dependent initialization are located in the module LowLevSys. Any future routines that depend on word size, byte order, etc. (none were used in the current implementation) would also be included in this module. The graphics primitives are located in module LowLevGrph. Screen handling routines (clear the screen, move the cursor, print a line, etc.) are located in the module LowLevScr. Fancy screen handling was avoided, thus allowing a few easily implemented routines to suffice. The remainder of the code should work on any computer with a C compiler which implements the buffed C I/O routines fopen, fread, fwrite, fclose, and fseek (most do). If the I/O routines are not available, then they can be implemented (with the same names and call sequences, so that the main code need not change) using the resources of that computer.

All constraints on array sizes, stack limits, etc. in the system were parameterized with "#define" statements in an include file, SysLimits.h. An attempt was made to have all procedures check on array overflow and to print an error message detailing the routine and the parameter that was exceeded. This should make it easier to tune and adjust the program or to increase the size of the problem that can be solved.

D O C U M E N T A T I O N

Documentation should not be left as an afterthought in system design and implementation, and it was not in this system. An updated version of the requirements document will become the users manual for the system. The high level and detailed design documents should provide excellent programmer documentation. Good documentation is a product of a detailed and thorough design.

C O N C L U S I O N S

DBA Systems will deliver to USAETL an overlay processor which will be able to efficiently solve larger problems than the current MOSS overlay capabilities. The new overlay processor will be easier to maintain and adjust, due to parameterization of systems limits, and a modular, structured design.

We believe that major modification and additions to the MOSS program family are simplified by adoption a "parallel system" strategy. That is, writing a subsystem that uses the existing data files and appears to the user as part of the same system, but does not attempt to re-use or interact with any of the existing code. This allows the system designer to use modern languages and software engineering techniques.

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Software Development Session

Section 5

MOSS Display: COS to COS3

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INTRODUCTION

During the mid 70's, development of the MOSS family of software began to take place. The Automated Mapping System (AMS) was developed to, enter geographical data, while the Map Overlay and Statistical System (MOSS) and the Map Analysis Processing System (MAPS) were developed to display and analyze geographical data. During preliminary use of these packages, it became clear that a hardcopy output system was also needed, thus the development of the Cartographic Output System (COS) began. The driving force behind the Cartographic Output System was the need for hardcopy output of MOSS products as well as cartographic production. The main purpose of COS was to allow non-technical users to produce high quality cartographic products in a relatively simple and efficient manner. COS software as other software of the MOSS family, has continued to evolve over the years. The subject of this paper is to introduce an entirely new version the Cartographic Output System, namely COS3.

COS3 was developed out of the need for a faster, more effcient output system. Development began around 1983, subsided for over a year, and resumed again in 1985. This new version of the COS is an entirely new software package, not an updated version of existing COS software. COS and COS3 do, however, share some functionalities as well as the same basic concept of graphic construction. The end product of either system is the same, a high quality cartographic hardcopy. The manner in which the final product is reached differs between the two systems.

BASICS OF ANY CARTOGRAPHIC OUTPUT SYSTEM

COS and COS3 have 4 basic functions: 1) graphic construction, 2) graphic editing, 3) graphic display, and 4) database maintenance. A graphic can be defined as the desired final product. COS and COS3 share the basic terms involved with graphic construction. The final product of either system is called a profile. The parts of the final product - map, barscale, grid, etc. - are called components. The components are composed of text, lines, markers, shading which are called primitives. Construction of a final product actually begins when primitives which are placed together to construct components. Components are placed together to create a profile or final product. This is the way in which both COS and COS3 approach creating a final product.

IMPROVEMENTS OF COS3

COS3 was developed to allow production of hardcopy outputs easier and more efficient. Three of the major improvements are the user interface, use of a stroke device and automation of rudimentary tasks.

User Interface

The COS command structure consists entirely of menus. There is a command mode in COS, but it is very limited. The COS3 interface is entirely command driven and is very similar to the MAPS user interface. Some prompting does occur, but for the most part the command and necessary phrases are required. Having a command driven as opposed to a menu driven system has implications throughout the entire system. The number of steps and the time involved with constructing, displaying or editing a graphic is shortened considerably with COS3 simply because of its command driven interface. Figure 1 illustrates this point by comparing the steps necessary for constructing and displaying a grid in COS and COS3.

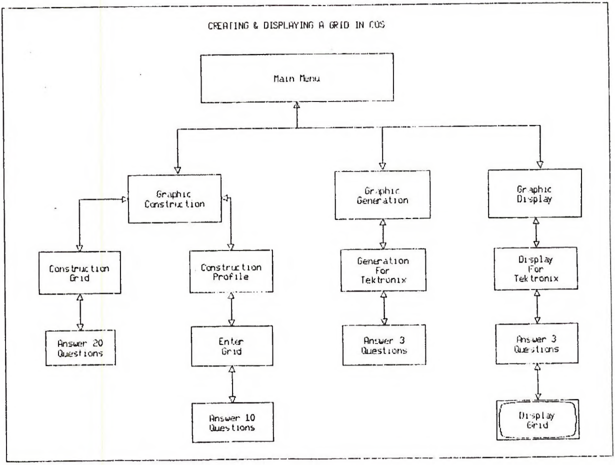
Stroke Device

A second improvement is the implementation of a stroke device. The stroke device or graphics cursor can be used to enter primitives into a component, place primitives and components, and to edit components and profiles. This makes construction and editing of components and profiles easier and more efficient.

Automation of Rudimentary Tasks

A third improvement involves automation of tasks that are commonly performed throughout construction of a graphic. Read files and bundle tables have been implemented to accomplish this. A read file is very similar to a macro in CLI. A file can be set up that contains commands that are frequently performed or necessary to perform in constructing a graphic. COS3 can be told to read from that file and the commands are performed accordingly. Read files are used in creating commonly used components such as barscales, legends, grids, and are used to perform other necessary tasks such as setting up and selecting the normalization transformation, setting the input and/or output devices. The second improvement in this area involves the use of a bundle table. All the primitives (text, line, markers, shade patterns) carry with them attributes. For example, attributes of the text primitive include character height and width, font #, and rotation. Each primitive has default values for each attribute, but these values can be changed at any time. The bundle table facilitates changing the attribute values of the primitives one at a time, a bundle table index can be assigned to the primitive. The attibute values for this primitive are then gotten from the bundle table. Essentially, the bundle table is similar to a large default table of attribute values. Whenever a specific group of values is desired, the specific index of the bundle table is addressed. This is especially useful when creating a graphic with many components that need to use the same attribute values.

Fig. 1



Creating & Displaying a Grid in COS3

1) Set up Normalization

2) Select Normalization

3) Create Component Command

4) Select Component Command

5) EGRID Command

6) PLOT Command

CONCLUSION

There are several functions of COS that have been carried over to COS3. For example, the generation of a log file when creating a plot fie, use of auxillary text files, and scaling of a graphic at the time of plotting. COS3 also uses the same line and text fonts and shade patterns as COS and MOSS. There are still several functions that need to be implemented in COS3 such as the ability to handle raster and AMS data as well as existing COS data.

A technical advantage of COS3 is its use of the Graphics Kernal System (GKS). The advantage of GKS implementation is that GKS is the standard for graphics programming, which introduces graphics flexibility and increases its portability to other systems.

In conclusion, the COS exists among the MOSS family of software to produce high quality cartographic products. COS3, the latest version of the COS, has been developed to further facilitate the production of cartographic products by simplyfying the procedures involved in producing the final graphic.

A GKS GRAPHICS INTERFACE FOR MOSS SOFTWARE

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A B S T R A C T

DBA Systems, Inc., under contract to the U.S. Army Engineer Topographic Laboratories (USAETL), is enhancing the AMS/MOSS software in the Terrain Analyst Work Station (TAWS) to permit graphic operations to be performed by software that conforms to the Graphical Kernel Standard (GKS).

With over 1000 routines in the Geographic Information Systems (GIS), it was decided to implement GKS graphics by creating a library of conversion routines that will satisfy existing calls to non-GKS graphics routines by subsequent calls to routines in Precision Visuals' GK-2000 software. The most important aspect of this development has been the design of an interface library to emulate current cursor positioning and to ensure data integrity. Current cursor emulation is achieved through an intersecting workspace that relates the two graphics standards to each other. Data integrity is maintained by a new layer of error processing software.

A benefit of this enhancement will be increased device independence and portability of the GIS software, which will be able to operate with any peripheral supported by the GKS graphics software.

I N T R O D U C T I O N

DBA Systems, Inc. is currently under contract to provide software maintenance and support for three Geographic Information Systems (GIS) at the U.S. Army Engineering Topographical Laboratories (USAETL). The GIS employed at the USAETL consists of three subsystems:

* Analytical Mapping System (AMS),
* Map Overlay Statistical System (MOSS), and
* Map Analytical Processing System (MAPS).

Graphic commands to the HP plotters and graphics terminals, rastertech graphics terminals, and Digital VT240 graphics terminals and TEKTRONIX graphics terminals are processed by DI-3000, a Core Graphics System (CORE) derivative. DI-3000 is a proprietary, device, independent graphic software package written and supported by Precision Visuals Incorporated (PVI). The DI-3000 graphic package, although a device independent package, does not rigorously adhere to a nationally recognized standard for graphics. Adherence to a nationally accepted standard would allow for greater flexibility and portability of software. As part of the development of a tactical battlefield GIS, USAETL decided to implement an internationally recognized standard, GKS (a Core derivative), which allows greater device independence than DI-3000 and a wider selection of vendor packages. DBA was tasked for the conversion and implementation of GKS into a VAX/VMS version of the GIS.

P R O J E C T   E N V I R O N M E N T

The hardware configuration of the GIS consists of: a VAX 11/750 computer running under the VAX/VMS 4.3 operating system, HP plotter, VT240 graphic terminal, ALTEK digitizer, and a RASTERTECH Model ONE/10 terminal. The existing GIS software originated from an HP-UX operating system and was converted to the VAX/VMS. Initially, the graphics operations were performed by a generic graphic library, Autograph, which provided an interface to the DI-3000 graphic package. The graphic calls made by the GIS are sent to the generic graphics library and are then passed onto the DI-3000 library of the actual graphic operation. Error codes within the GIS during graphic operations are set according to the DI-3000 error codes.

The conversion required that the DI-3000 graphic package be replaced by a GKS graphic package. GK-2000, a GKS package developed by PVI was selected for use on the VAX/VMS development system. The only limitation of GKS is that the vendor package must also provide the I/O driver for GKS to interface with. This limits the GKS package selected to only the devices supported by the vendor. Hereafter, references to GKS refer specifically to GK-2000.

The conversion effort of MOSS DI-3000 graphics to GKS requires specific software capabilities to be in place within the GIS. First, the existing code that properly handles error conditions from the graphic interface routines must already be in place. The new code being developed and tested for the conversion effort has its own layer of error processing and without this first assumption, further definition and testing of the existing error handling code would need to be accomplished to assure it is properly functioning. In other words, during development of the original code, thorough testing is assumed to have been completed so that pre-existing logical errors do not hinder or lengthen the DI-3000 to GKS conversion effort.

Second, GKS does not support three dimensional drawings; therefore, any requirements for three dimensional drawings must be handled by low level graphics routines as part of the graphic subsystem. The current GIS three dimensional display capabilities allow a three dimensional image to be projected onto a two dimensional (x,y) plane. This image can then be plotted by GKS, which is only two dimensional. This two dimensional restriction is a consideration for analysts considering a conversion to GKS because it will limit or change the requirements for future development of applications if three dimensional drawings are desired.

Third, no specialized device features can be present. The current MOSS code utilizes some escape sequences for clearing screens or positioning cursors. The use of escape sequences, which are device dependent, will result in loss of portability. All device dependencies must be identified and resolved for an effective implementation of GKS.

A L T E R N A T I V E S

Reviewing the task of converting from DI-3000 to GK-2000, DBA evaluated two different approaches. One employs an interface library design, such as the generic graphic library already in place, to provide an intersecting workspace in which to convert the parameters of DI-3000 to meet the parameter requirements set forth of the newly designated GKS package. The other involves coding the necessary parameter changes directly into the source code required for the new package.

Option one, the interface library design, has distinct advantages. With an interface library, all parameters from the source code remain unaltered, thereby requiring no modifications or recompilations of the source code. During the testing phase, all changes made to convert current parameter requirements have taken place in the interface library delineating where an error might occur to one routine vice several routines. If changes were made directly into the code, as mentioned in option two, a logical or syntax coding error relating to a graphic call discovered in one routine would most likely require changes in all routines relating to the same graphic operation. Also, within the interface library, error codes of GKS calls can be checked independently of the source code error handling already in place. If an error does occur in the interface library, affecting operation of the GIS source code, an appropriate parameter can be set and returned to the GIS source code for appropriate handling according to previously defined error handling requirements.

The second option was rejected as a possible approach due to the considerable amount of time required and the lack of flexibility. For option two to have worked, all graphic calls within the source code would need identifying and the source code modificated to replace all calls with the new parameter requirements of the newly targeted graphic package. With over 1000 routines within the USAETL GIS, this would require tremendous maintenance and recompiling time for the routines. Also, error checking was currently being done in accordance to the existing graphic interface package error codes and the targeted GKS graphic package did not always conform to the same error codes for unsuccessful events. Hence, complete analysis and modification of error handling code within existing routines to properly handle unsuccessful events would be required.

D E V E L O P M E N T   P R O C E S S

First, all DI-3000 calls were identified along with parameter requirements for the calls. The corresponding GKS functions and their specific parameter requirements were then identified. The difference between the parameter requirements for DI-3000 and GKS were then used as input to the design of the interface library which resolves the parameter differences. Figure 1 shows the flow of the data from the GIS source code into the intersecting workspace where the parameter requirements are made compatible to GKS and then passed to the actual GKS library.

FIGURE 1

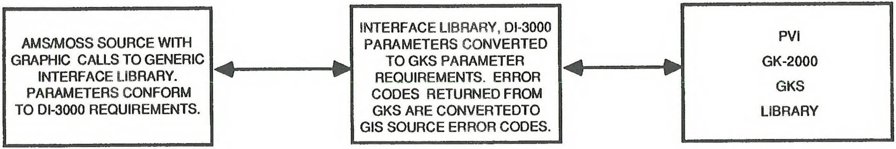


Figure 1. Functional Overview

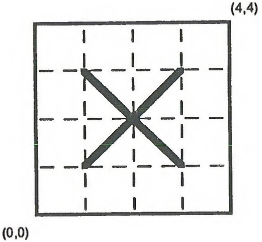
The second step of the requirements was to identify the error handling procedures of the GIS source code. The data gathered from this portion of the requirements was then implemented in the design of the interface library in which GKS errors will be converted to meaningful error codes of the GIS source code. All calls to the existing generic graphic package had a parameter to handle the passing of error codes to and from the existing library and this parameter was utilized again within the new interface library.

Following the requirements definition, the design of the interface library was started. The design of the interface library consisted of the following:

* Functional description of the subroutines needed
* Inputs
    - All initializations required for GKS
    - All device initialization required for the GIS source
    - All deinitializations for GKS
* Outputs
* Processing method
    - Emulation of current cursor positioning
    - Conversion of DI-3000 parameter requirements to GKS parameter requirements
    - All handling of GKS error codes and conversion to meaningful GIS source error codes

One of the major efforts within the interface library design was to handle the relative moves and draws and current cursor position supported by DI-3000. GKS does not support the process of current cursor position. The current cursor position is emulated in the interface library and the design was to place the emulated current cursor position in a common block for access by the other interface library routines. Current cursor position is the current (x,y) coordinate position from which the next graphic operation is to be performed, whether a draw or move. Relative moves and draws are used to draw about a given current cursor position, mostly to draw diagrams or symbols about a given center or starting point. Figure 2, shows the concept of relative moves and draws required to place the symbol x in the center of the depicted box, and the current cursor position resulting from the moves and draws. The box is depicted in world coordinates and the moves and draws are given in world coordinates. The generalized code depicting the drawing of the 'x' is given with the diagram.

FIGURE 2



COMMANDS	CURRENT CURSOR POSITION AFTER COMMAND
1) MOVE -ABS (2,2)	(2,2)
2) MOVE-REL (1,1)	(3,3)
3) DRAW-REL (-2,-2)	(1,1)
4) MOVE-REL (0,2)	(1,3)
5) DRAW-REL (2,-2)	(3,1)

Figure 2

The first move depicts a move in absolute world coordinates to the center of the box, updating the current position, and the remaining draws and moves are depicted as relative movement about the current cursor position. Relative move and draw parameters are displacements, in world coordinates, about the current cursor position. Each move changes the absolute current cursor position to the next starting point for the next graphic operation. As mentioned, GKS does not support current cursor position. For DI-3000, the starting (x,y) coordinate pair of a line is given by being equivalent to the current cursor position updated by either a move or draw command. When a line is drawn in DI-3000, only the ending point (x,y) coordinate needs to be identified. Figure 3, depicts the drawing of a line in DI-3000 in absolute world coordinates.

FIGURE 3

For GKS to draw the same line, the call to GKS must contain both the starting and ending (x,y) coordinate pair. To do this the interface library must emulates the current cursor position so that a starting (x,y) coordinate is stored globally as in DI-3000. After initialization of GKS, the current cursor position is (0,0). Any move or draw subsequent to initialization, updates the current cursor position and variables are then appropriately updated to be used as the starting (x,y) cursor position coordinate pair in a draw for GKS. Figure 4, is an example of how the GIS would draw a simple line and how the interface library would update the emulate current cursor position with a call to GKS to finally draw the line.

FIGURE 4

COMMANDS

.
.
.
MOV.ABS (2, 2)
DRAW.ABS (4, 4)

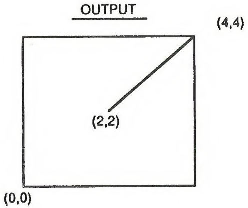


Figure 3. Line Draw With DI-3000

GIS

```
.
.
.
CALL MOV.ABS (2, 2)
CALL DRAW.ABS (4, 4)
.
.
.
```

INTERFACE

```
.
.
.
X(1) = 2  ! UPDATE CURSOR POSITION
Y(1) = 2  ! AND USE AS STARTING POINT
.
.
.
X(2) = 4  ! LOAD ENDING POINT
Y(2) = 4  !

<CALL GKS TO DRAW LINE WITH
ARRAYS X & Y CONTAINING
START AND ENDING POSITION>

X(1) = X(2)  !LOAD NEW CURSOR POSITION
Y(1) = Y(2)
```

OUTPUT

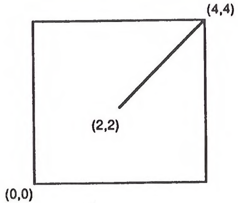


Figure 4. Line Draw Using Interface Library & GKS

The first section shows how the GIS would call the graphic interface routine to move to a starting point and then draw a line. The first call to the routine which handles moves just simply updates temporary variables emulating the current cursor position which then are used as the starting (x,y) coordinate for a line draw. No call to the GKS library is necessary. The second call from the GIS to the actual draw gives the ending (x,y) coordinate. The starting and ending (x,y) coordinate pairs are then loaded into a two dimensional array for GKS format with $(x(1),y(1))$ equivalent to the starting point and $(x(2),y(2))$ equivalent to the ending point. After the variables are then updated with the ending (x,y) coordinate pair because they are now the new starting point for the next draw or move. This shows that the current cursor position from relative and absolute moves can be kept and then reused for the starting point for the drawing of a line. It is essential that all current cursor position updates are captured and the temporary variables updated appropriately to ensure the next call to a line draw is started from the correct (x,y) coordinate.

The use of relative moves and draws was depicted earlier. The current GIS software for USAETL utilizes the relative moves and draws only to draw the symbol 'x' about a given point. The GKS software supports the drawing of symbols. By referencing the symbol desired and calling a routine to draw the referenced symbol, the relative moves and draws within the GIS could be removed. It is more efficient to utilize the capabilities of GKS to draw the symbol then to use relative draws and moves.

The error processing built into the interface library handles the error codes returned from GKS graphic operations and converts the error code to a meaningful GIS error code. This requires a full understanding of current error handling within the GIS to assure the GKS error code is transformed to an appropriate GIS code. For example, the GIS code might have predetermined error codes to handle specific error conditions. If a graphic operation results in one of the predetermined errors after a GKS graphic operation, the returned error code from the GKS operation must be converted such that it is a meaningful error code when returning to the source code. Figure 5 depicts an example of converting an error code returned from GKS to compatibility with the GIS code.

FIGURE 5

The GIS source code calls the interface library with the error code set to zero. The interface library then proceeds to call the GKS library to perform the graphic operation, but is unable to complete successfully. The error code returned from the GKS library is equal to some number designating specifically

GIS

```
.
.
IER = 0
CALL DRAW (X, Y, IER)
IF (IER .NE. 1) THEN
   IF (IER.EQ.-1) THEN
.
.
.
      IF (IER .EQ. -2) THEN
.
.
.
      ENDIF
   ENDIF
ENDIF
CONTINUE
.
.
.
```

INTERFACE

```
CALL DRAW (X, Y, IER)
IF (IER .EQ. 77) THEN
   IER = -1
ENDIF
.
.
.
RETURN
```

GKS

```
<RETURN ERROR
CODE 77>
```

Figure 5

the error incurred. Upon return to the GIS code,the status of the error code is checked for successful completion, which in this instance is when the returned code is equal to one. If the error code returned is other than one, a branch to handle the specific error returned is accomplished. Because the graphic operation was unsuccessful, the error code parameter to be returned must be set to a meaningful value, in this case either a -1 or -2, such that appropriate action is taken.

CONCLUSION

The areas of greatest effort in the conversion were the processing methods of current cursor position, relative moves and draws, and error handling. Significant bugs were discovered during testing that involved the current cursor position. All calls affecting the current cursor position had not been identified and needed to be debugged with appropriate change to correct the errors. The other area requiring a significant amount of time during the testing phase was determing proper operation of GKS in relationship to the host operating system. Specific requirements were not properly met during installation of the GKS package and therefore, resulted in some errors.

The conversion effort alone, was successfully completed on time and under budget, but it was determined that after the conversion effort was completed, the graphic terminal being utilized for the software converted is not currently supported by GK-2000. This was not a problem, though, because of the standardization introduced by GKS. The GIS converted to GKS is part of a much larger system which has an interface library to convert the GKS calls to the targeted terminal's graphic language.

The conversion effort has resulted in greater portability and has given flexibility for USAETL managers to more effectively plan conversion to other host systems of the converted GIS while making the only requirement for graphic operations to be that a GKS compatible graphic package installed on the host system, irrelevant of vendor.

DEVELOPMENT OF A STANDARD LINEAR FORMAT (SLF) IMPORT/EXPORT CAPABILITY FOR AMS

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ABSTRACT

Digital data products for cartographic, land-use, and tactical applications are becoming increasingly available. A variety of products are centrally produced for internal, inter-agency, or commercial distribution by such agencies as USGS, DMA, USDA, SCS, NOAA, and NASA. Standard data formats are under development to facilitate transfer of digital map information on magnetic tape among potential users in the GIS community. GIS software packages are designed to create internal data bases directly from source documents and vary in their capacity to integrate digital data products.

DBA Systems, Inc., under contract to the U.S. Army Engineer Topographic Laboratories (USAETL), is enhancing AMS to allow the use of SLF terrain analysis data from the Defense Mapping Agency in the Terrain Analyst Work Station (TAWS). This paper discusses the interface of SLF data to AMS, and concerns for importing multiple attribute digital data to a GIS.

INTRODUCTION

The SLF Throughput System was designed as an enhancement to the Terrain Analysis Workstation/Geographic Information System (TAWS/GIS) at the U.S. Army Engineer Topographic Laboratories (USAETL) at Fort Belvoir, Virginia. The TAWS/GIS operates a version of the AMS/MOSS/MAPS software that was originally developed under government contract for the U.S Fish and Wildlife Service, and includes modifications subsequently developed under contract to USAETL.

The purpose of the enhancement is to provide an interface to the TAWS/GIS to accept Standard Linear Format (SLF) digital data produced by the Defense Mapping Agency (DMA). The SLF Terrain Analysis data (SLF/TA) is a digital version of a Terrain Analysis hardcopy product at a 1:50,000 scale. The data is in the form of thematic overlays of various terrain features (eg., soils, vegetation, slope, transportation) for a particular coverage.

Terrain information produced at a central location may not be current or contain a sufficient level of detail required for tactical purposes. Map data must be updated according to the latest field information: new features may be added, boundaries of existing features may be changed, or existing features may be described at a level of detail not present in the source data. The SLF data structure provides the flexibility to accommodate various products at different stages in their production. There was a clear need to provide a

mechanism within the existing system of the TAWS/GIS to employ this data.

Specific requirements that were met by this prototype system for throughput of the SLF data in the TAWS/GIS include:

* Transfer of the SLF/TA data from magnetic tape to the AMS subsystem of the TAWS/GIS

* Export of locally created data to an SLF tape for transfer to other installations.

* Examination of alternatives for importing and using a digital data base with multiple attributes for map features.

The SLF throughput software was developed to perform on a Hewlett-Packard 9030 computer, operating HP/UX version 5.0, at USAETL. Initial development of the system took place on a VAX 11/750, operating DEC/ULTRIX version 1.1.

SLF INPUT DATA

SLF is designed by DMA to be a portable, flexible and efficient data structure for exchange of digital cartographic data via magnetic tape (DMA, 1985). It is intended to become a standard DMA product. SLF/TA data used in the TAWS program is produced on the Terrain Analysis Production System (TAPS) at DMA and conforms to FIPS/ANSI standards with all data in ASCII characters. This data is a digital version of the DMA TA hardcopy products at a 1:50,000 scale. A SLF data file will normally correspond to a map sheet overlay describing a type of terrain feature (eg. surface materials, vegetation, slope or drainage). It is a vector data structure that describes the point, line or aerial feature components of the original map plus the attribute information for the features. The format of the SLF data, the physical tape blocks, and the logical record fields are documented in DMA, 1986.

SLF maintains DSI, SEG and FEA records. The DSI, or Data Set Information, contains the header parameters, history and specifications of the data file. The SEG record contains the segment and coordinate data, and the FEA records contain the attribute description of the map features. Integral to SLF is the "chain-node" structure which requires that a segment chain be stored only once regardless of the number of features which it bounds. This eliminates double storage of common boundaries. SLF stores the segments and provides linkages to the features. The linkages allows the feature to be reconstructed from its component segments. Figure 1 illustrates the cross-referencing between features and segments.

A variable length feature header record is provided for product specific descriptive information at the feature level. The overall format is defined by SLF but the length and contents of the feature description are defined in product specific appendices. Figure 2 shows

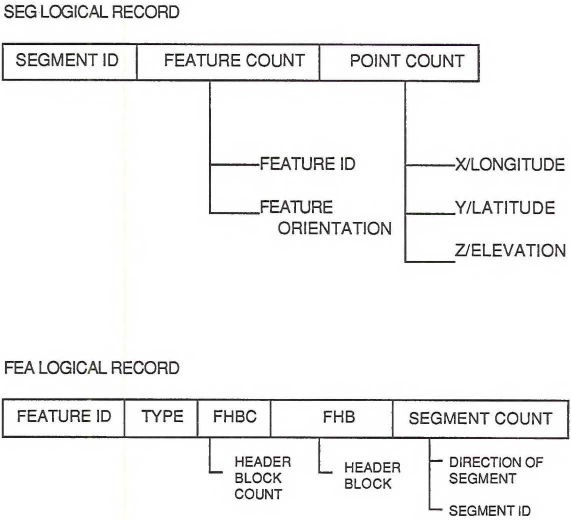
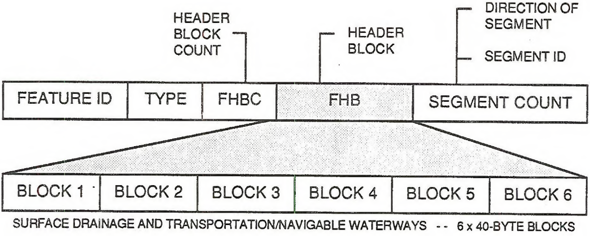


Figure 1. SLF Logical Record Structure of the SEG and FEA Records. The Segment ID and Feature ID are Pointers that Link the Two Record Types.



<u>BLOCK 1</u>

ITEM NAME:
Feature Category
Original Feature ID
Security Classification
Attribute Format
Map Unit Code Symbology

<u>BLOCK 2</u>

ITEM NAME:
Overlay Assignment
Reserved2

<u>BLOCK 3</u>

ITEM NAME:
Name
Map Unit Code:
Drainage Type
Gap Width - Code
Bottom Materials
Bank Height, Right - Code
Bank Height, Left - Code
Bank Slope, Right - Code
Bank Slope, Left - Code
Water Velocity - Code
Depth of SD - Code
Water State Qualifier
Traversing Feature Class
Condition / Usability
Contamination
Potability
Water Stage
Water Accessibility
Bank Slope, Right - Low
Bank Slope, Right - High
Bank Slope, Left - Low
Bank Slope, Left - High
Elevated Qualifier
Water Velocity - Low/Actual
Water Velocity - High

<u>BLOCK 4</u>

ITEM NAME:
Water Velocity - High
Vegetation / Obstruction
Storage Capacity - Low
Storage Capacity - High
Storage Capacity - Code
Length - Low / Actual
Length - High of Range
Length - Code
Channel Width - Low / Actual

Figure 2. Expansion of a FEA Logical Record Showing Some of the Data Fields Present for a Surface Drainage and Transportation / Navigable Waterways Feature. (Blocks 5 and 6 not shown)

an example of a Feature Description format for surface drainage features.

OVERVIEW OF THE IMPORT PROCESS

A requirement of the SLF throughput specifies the capability of making modifications to the source SLF data. For this reason the Analytical Mapping System (AMS) was chosen as the GIS subsystem to receive the SLF data. AMS is the data input and editing component of the TAWS/GIS. AMS was designed to create a database locally through manual digitalizing of hard copy maps, or through an analytical stereo-plotter or light table mensuration system for input of aerial photo source data. The Map Overlay Statistical System (MOSS), which is the analysis and overlay component of the GIS, does have an existing format to receive external data (via the ADDWAMS system). However, MOSS does not allow topological modifications to the existing data base as does AMS.

The enhancement for importing digital data to AMS requires a detailed specification of internal AMS data files and knowledge of operational procedures so that the system will recognize the "foreign" data.

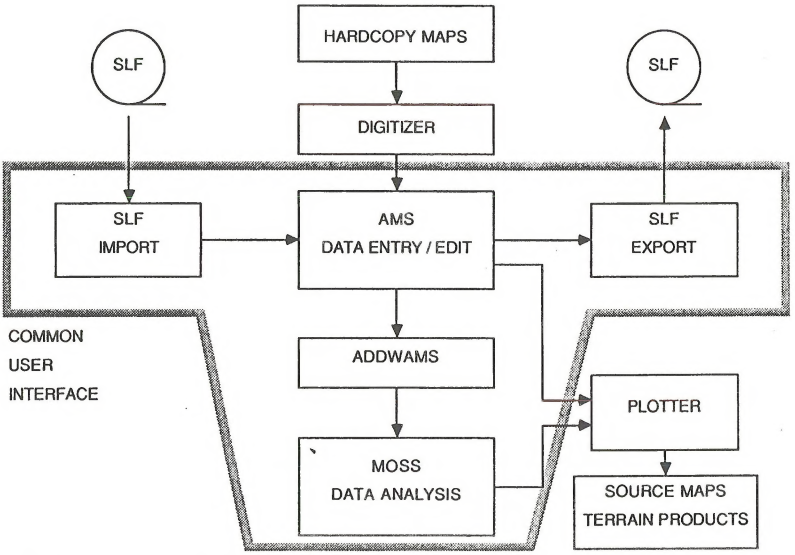
The system performs the following functions:

* Displays a listing of the data files on the SLF tape
* Provides a formatted dump of a data file contents
* Creates a Summary Report of the contents of each file
* Performs a partitioning of the source data so that it can be imported to AMS as individual subsets of the original coverage.
* Creates valid AMS data files from the SLF topology so that data can be displayed, plotted, registered on a base map, updated/edited, verified, and databased.
* Creates an SLF tape from AMS data files

The SLF throughput system consists of five separate programs. These programs are logically connected by a shell script and involked by selecting the desired program from a menu. This approach makes the system user friendly. The following programs are defined to provide the basic requirements of the interface:

* Provide a tape summary of the source SLF tape (TAPESUM)
* Geographic panelling of the original coverage to six subset areas (DIVSLF)
* Import the source file and build topological AMS data files (IMPSLF)

CONFIGURATION FOR SLF THROUGHPUT IN THE TAWS GIS



* Provide a formatted dump of the SLF tape contents (SLFDMP).

* Export AMS data files to a SLF formatted tape (EXPSLF).

The Import procedure creates a set of AMS data files from the SLF source data. The new data files reside in the user's work area directory and specify a "geounit" within a particular AMS Project/Theme which the user has set up prior to the Import SLF job. The AMS software is not modified by the enhancement except to add another menu option to the start-up menu. The main programs are called via a secondary menu. After the import is completed, the user can register the data to a base map for editing purposes or proceed directly to AMS verification of the data and move the files to the database directory (AMS functions). Once in the database area, the data can be brought back for update, or be exported to the MOSS analytical package of the TAWS/GIS.

If the Subset SLF function is used, a set of six disk files, GE01-GE06, will be created in the user's directory. These files contain source SLF data that has been panelized (geographically divided) into 6 subareas. Each panel can be imported as an AMS geounit.

AMS FILE STRUCTURE

AMS maintains a set of internal, random access disk files associated with an input job (Figure 3). The data structure is an "arc-node" structure that explicitly identifies all the topographical elements including segments, nodes, edge nodes, polygons, and coordinate data. Each entity type is contained in a special file. A system of file pointers exist to cross-reference all the connected elements and allows the software to maintain the integrity of the data base when topological elements are added, deleted and modified.

The "arc-node" data structure used in AMS can be created from the simple chain-node structure of SLF with some restructuring and creation of new information unique to the AMS data structures. An example of this restructuring is the creation of the AMS "Normal Node File". Nodes are important elements in an arc-node data structure. They define the junction where two or more segments come together. In SLF, nodes are not explicitly identified, but are simply the first and last points on a segment "chain". The SLF import process identifies these points as nodes and assigns linkages required by AMS to identify the segments that join at a particular node. The structure of the Normal Node File, including pointers, is maintained as nodes are added.

ATTRIBUTE HANDLING

SLF/TA format provides a hierarchical arrangement of descriptive information for map features (Figure 2). The SLF feature description can be of variable size, depending on the feature type and the amount of information collected. The format does not 'map' well into the AMS structure for map feature attributes. Attribute tags in AMS must be

AMS DATA FILES

Record in the SEGMENT INDEX FILE (SIF)

* Pointers to record in the SCD file
Left, Center, and Right feature attributes
* Pointers to POL for Left, Center, and Right features
* Pointers to NNF and ENF for beginning and ending node
Minimum bounding rectangle of segment

Subrecord in the NORMAL NODE FILE (NNF)

Latitude coordinate of node
Longitude coordinate of node
Number of segments attached to node
* List of record numbers in SIF

Record in the SEGMENT COORDINATE DATA FILE (SCD)

Number of coordinates in this record
Minimum bounding rectangle of this record
List of coordinate points

Subrecord in the EDGE NODE FILE (ENF)

Delta longitude (for an edge on the North or South edge)
Delta latitude (for an edge on the East or West edge)
* Record number in SIF for segment attached to the edge node

Record in the POLYGON FILE (POL)

Feature Number
Minimum bounding rectangle of feature
Area of feature (if polygon)
Centroid of feature
* Type of feature (point, line polygon)
Pointers to SIF for segments that make up this feature

RESTART FILE

Contains job parameters for updating and displaying geounit

Figure 3. List of Major Data Files Required by AMS and Created by the Import Process (Except POLYGON), with an Abreviated Listing of the File Contents. An Asterisk Indicates the Field is a File Pointer.

contained within a 32 character field. For practical purposes, only 18 of these characters are displayed to the user.

The interim solution adopted here is to save the SLF feature descriptions in a separate disk file during the import process. A standard feature description item, the Feature Category, or FEACAT code, is extracted for every feature in the data set and combine with the feature ID number to form the AMS attribute.

CONSIDERATIONS FOR IMPORTING MULTIPLE-ATTRIBUTE DATA

There are several alternatives for using the full feature descriptions provided by SLF. The specific approach will depend on the target system to receive the imported data, the method used for analysis of the data, and the generality desired in the import software.

Considerations for importing data to AMS must take into account that the software uses a single attribute tag for the map feature. At USAETL, the TAWS project uses a coding scheme to describe levels of information for each map feature. The coding scheme is entered when the data is digitized. Creation of terrain products in the MOSS subsystem are based on decoding a particular coding schema. One alternative for importing SLF multiple attributes would be to compress the contents of the Feature Description record into an appropriate character code. This approach involves a rule-based matching of data fields from the feature records to a locally used coding scheme. While this approach has minimal impact on existing methods for data analysis, it is limited to a particular system. Also, information from the source data may be lost in the process of compressing data fields to a coded representation.

A more generalized approach would allow the user to access any and all attribute fields that may be present in the imported data. A digital data product, such as SLF, contains varying levels of detail. The user may want to preview future information on tape to determine what may be present. The import utility would have the capability to down-load the feature information to a multiple-attribute database. The structure of the feature database could be tailored to conform to a MOSS multiple attribute file. If a data base management system were integrated to the GIS, the import software could create a generic "flat" file that could be accessed by the DBMS. These alternatives are currently being considered.

Current developments in digital cartographic exchange formats emphasize the need for flexible descriptions of map attribute data (Guptill, 1986). In order for these data products to be fully exploited by the intended users, it is important that the GIS software be able to access the feature description component of the data product with convenience and flexibility.

CONCLUSIONS

An enhancement to AMS was developed to import a digital cartographic data base from magnetic tape. The current version translates Standard Linear Format (SLF) data to internal AMS data files. Alternatives are being considered for importing the multiple-attribute component of the SLF data product. The modular design of the system will allow a modification to import any standard vector data product with an arc-node structure (eg.USGS Digital Line Graph) to the AMS data base. The principle advantage of importing data to AMS rather than MOSS is the capability in AMS to make changes to the source data.

REFERENCES

Defense Mapping Agency (1985) Standard Linear Format (SLF) For Digital Cartographic Feature Data, Edition 2.0 (Draft).

Guptill, Stephen C. (1986) The National Digital Cartopgraphic Data Base - Next Generation. Technical Papers of the 1986 ACSM-ASPRS Annual Convention, Vol. 1, Cartography and Education, Page 218.

Basic System Applications Session

Section 6

USING GIS IN DETERMINING COMMERCIAL DEVELOPMENT SITES FOR NAMBE PUEBLO

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ABSTRACT

MOSS proved to be a vital key in helping resource managers prepare the Nambe Natural Resource Management Plan. A portion of this plan addressed potential sites for expanding commercial development. Using a Geographic Information System (GIS) allowed the combining of slopes into various categories and relating these to location and soil types. Final analysis consisted of prioritizing these areas and producing outputs showing location and acreage.

This analysis demonstrates that MOSS/MAPS is useful in providing results that aid in non-resource decision making. Simply stated, site characteristics determine building costs and accessibility in developing commercial sites.

INTRODUCTION

The Bureau of Indian Affairs (BIA) Albuquerque Area Office (AAO) administers 24 reservations/pueblos in their jurisdiction. The BIA is required to prepare Natural Resource Management Plans (NRMP's) for each one of these. In 1984, steps were taken to begin preparing a NRMP for the Nambe Pueblo. This reservation was chosen to begin using GIS as this is a smaller pueblo and yet possesses a wide variety of natural resources. This allowed the opportunity to gain experience using GIS before attempting a larger scale project elsewhere.

The Nambe Tribal Council submitted the Tribal Goals and Objectives (G&O's) to the BIA. Contained in this was the desire to "Provide for Potential Commercial Development (PCD) Sites". The Map Overlay Statistical System (MOSS) and Map Analysis and Processing System (MAPS) was used to determine these areas along with addressing other G&O's.

DISCUSSION

Procedures

The NRMP team consisted of 13 individuals. This team defined the requirements for determining PCD Sites. The requirements were: (1) must be located within 1/4 mile of existing roads to minimize immediate costs, and (2) categorize land slopes into three groups. Knowing these requirements allowed the determination of data themes needed to perform analysis.

There were 21 data themes digitized and available to use with MOSS. The themes applicable to use in this analysis were: (1) Reservation Boundary, (2) Roads, (3) Soils for the Nambe Irrigation Project (NIP), and (4) Soils for the remaining Nambe Pueblo (NIR). There were not any Digital Elevation Models (DEM's) available from the United States Geological Survey (USGS) to perform slope analysis. This necessitated using the two Soils themes as these contained the only available slope information. The soil attributes categorized soils into various slope ranges.

Categorizing Slope Data

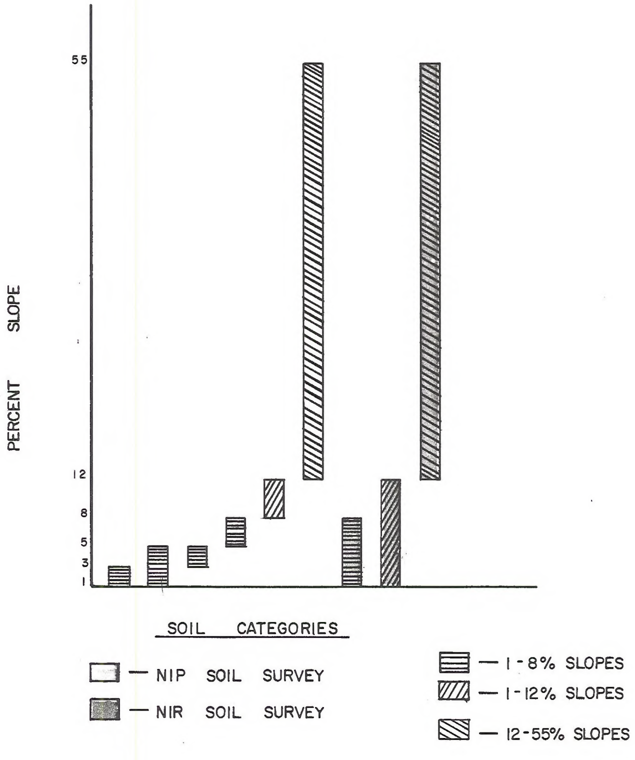
The soils information used eight different slope categories. Figure 1 shows these slope categories. As this illustrates, there is an overlap between most of the categories. The NRMP team chose to divide these categories into three groups. Admittedly, two of the groups overlap with one another (1-8% and 1-12%). The only way not to have overlaps is if there were only two categories used (1-12%, 12-55%). This was not done as a 1-12% slope group is too broad.

Analysis

Each data theme for the Nambe Pueblo is organized by USGS 7.5' quadrangles. The Nambe Pueblo extends onto four of these quadrangles. Due to this, it was required to merge the quadrangles for each theme to allow for reservation-wide analysis. This merging enabled simpler and faster analysis.

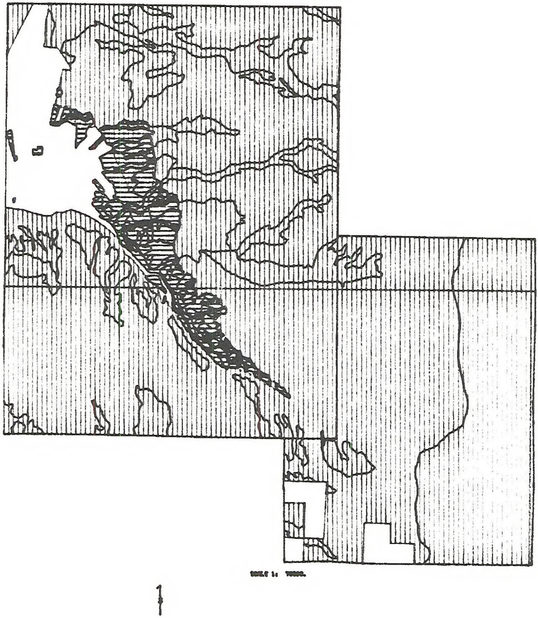
After merging each theme, the three slope groups were selected for the two soil themes in MOSS and plotted to a graphics terminal. At this point it was noticed that their were overlaps between the soil inventories (Figure 2). To make the analysis more accurate, the data must be "cleaned-up" before merging the slope groups of the two soils themes. To make this easy and fast, it was determined to perform this "clean-up" using MAPS.

FIGURE I



PERCENT SLOPE
55
12
8
5
3
1
SOIL CATEGORIES
— NIP SOIL SURVEY
— NIR SOIL SURVEY
— 1-8% SLOPES
— 1-12% SLOPES
— 12-55% SLOPES

FIGURE 2



MAP LEGEND

Since data must be rasterized to use MAPS, the cell size must be determined. At this point, the distance to paved roads requirement for PCD sites was used. Sites must be within 1/4 mile (1,320 feet) of paved roads. Next, cell height and width was calculated for various cell sizes. It was observed that .4 acre cells using a ratio of 1, are 132 x 132 feet. Using this cell size means 10 cells will equal a 1/4 mile exactly. Each theme was then rasterized to .4 acre cells using the RASTERIZE command in MAPS.

The soil survey for the NIP was determined to be a more intense survey than the NIR soil survey and, therefore, a more accurate data base. Each slope group in the NIP soils theme was used to "cookie cutter" the NIR soils removing overlaps from the NIR soils theme. This was accomplished using the BOOLEAN command in MAPS. After this was finished, the two soil themes were merged together making one slope theme consisting of three groups.

Next, the paved roads theme must be combined with the slopes theme to determine those slopes within 1/4 mile of the roads. This was accomplished using the PROXIMITY command in MAPS. Figure 3 shows the results of this analysis. From the new map created, an acreage summary for each slope group that meets the PCD site requirements is listed.

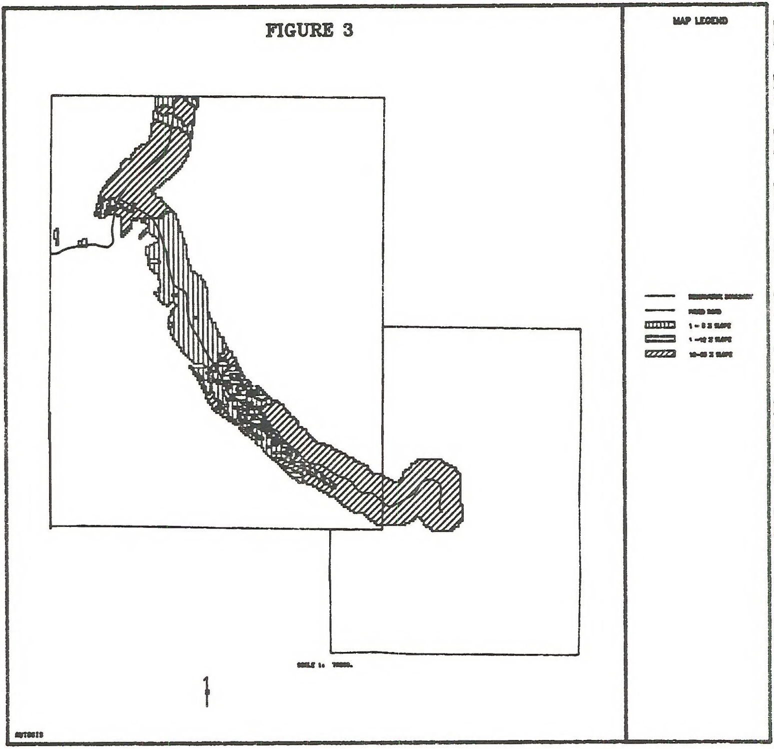
1 - 8 % slopes	862 acres
1 -12 % slopes	130 acres
12-55 % slopes	1,503 acres
TOTAL	2,495 acres

CONCLUSION

This analysis provides a good example of how GIS can be used to resolve planning problems. GIS does not necessarily need to analyze natural resource conflicts. The information obtained can help the Nambe tribe determine PCD sites. Depending on the type of commercial development the tribe desires, the appropriate desired slope for the development can now be located and identified. The 1-12 % slope category will necessitate an on-ground inspection as it too has areas that are in the 1-8 % slope range. For a more dependable slope breakdown, the 1-8 % and 1-12% slopes can be combined creating a 1-12 % slope group that has no overlaps. This group and the 12-55 % slope group creates two distinct slope classes.

This analysis will probably be repeated during FY88 when DEM's are created and purchased for the Nambe Pueblo area. This will provide for more reliable slope information and also the ability to choose an exact slope range.

FIGURE 3



MOSS/MAPS ROUTINE USED IN PREPARING A TIMBER SALE

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ABSTRACT

This paper presents a specific routine of MOSS/MAPS commands used in displaying the natural resources on 30,000 acres of forested land on the Fort Apache Indian Reservation, and in analyzing the use of that land by the cattle, timber, recreation, and tourism industries. The materials generated by these procedures were used in presenting a proposed sale of timber on that land to the Tribal governing body. It was generally agreed that this first comprehensive integration of a computerized Geographic Information System (GIS) into forest management procedures represents a significant step forward in the Agency's management of timber, and holds promise of affecting a major change in Tribal-Bureau efforts in jointly managing tribal natural resources.

INTRODUCTION

A computerized Geographic Information System (GIS) is being used by the Bureau Of Indian Affairs to prepare maps and accomplish analysis in support of forestry operations on the White Mt. Apache Reservation in Arizona.

The hardware includes a Data General 20 with 142 MB of disk storage, a Hewlett Packard 7585 plotter, a CalComp 9100 digitizer, and three Visual 500 graphics terminals. The software used in preparing data for this paper was version 8509 of the BLM MOSS.

Reservation economic activity involving natural resources includes an annual harvest of 80 million board feet of timber, a range herd of 15,000 head of cattle, a ski resort, and various outdoor recreation activities including guided elk hunts priced at about $10,000 per hunt. Additional justification for use of a computerized GIS includes a tribal water rights suit against the State and Federal governments, and a billion dollar suit against the Federal government for mismanagement of Tribal natural resources.

This paper discusses some of the MOSS/MAPS commands used in analyzing the interrelationships of the pertinent natural resources in preparing a timber sale for approval by the tribal governing body.

GOALS FOR THIS PROJECT

Display areas proposed for <u>no</u> logging or <u>minimal</u> logging;

- Streams
- Lakes
- Campgrounds
- Cienegas
- Eagle/Osprey Nests
- Elk Hiding Cover

Display areas proposed for <u>seasonal</u> logging;

- Certain Soils
- Elk Calving Areas
- Elk Migration Routes
- Hunting Areas

Calculate impact of above on timber industry.

Do various Sorts for Forest Management Planning.

STRATEGY

The sequence of MOSS/MAPS commands we used was dictated by;

Inadequacies of some commands;

BUFFER	- So	use MAPS
OVERLAY	-	use MAPS
INTERSECT	-	use MOSS
HEWLETT	-	use MOSS

Use of a non-quad format;
use MAPS

Complex vegetative cover map;
use MAPS

Inevitable request to sort/select from final map;
use MOSS

Those conflicting requirements and needs result in procedures that are time consuming, interim products that are not entirely satisfactory, and the need for a higher operator skill level than would otherwise be necessary.

PROCEDURES

The first step in the routine was to reformat all of our themes from quad format to timber management unit format. (Commands are capitalized; MOSS commands are underlined, MAPS not);

SELECT, using the `subject' option, the desired timber management unit from the 7 1/2 minute quad timber management unit theme map. Do the same for the other four quads containing that management unit.

MERGE those five new maps, creating the timber mgm't. unit theme. The above two operations take 5-10 minutes. (Use DISSOLVE if you have the Jan. 87 BLM version of MOSS.)

SELECT, using the `All' option, the five vegetative cover maps which encompass the timber mgm't. unit. 5-10 minutes.

MERGE those five vegetative cover maps. 1 hour or so. (Several hours with DISSOLVE.) Repeat the above two steps for Roads, Streams, Lakes, Soils, Public Land Surveys, Springs, etc..

WINDOW the mgm't. unit map.

OVERLAY the mgm't. unit map on the five quad vegetative cover map, using the Yes option, 0 characters from the first map, and 15 from the second (15 characters in the vegetative cover map's subjects), using the intersection option. Go home for the weekend. Repeat the above two operations for each of the polygonal themes.

WINDOW the mgm't. unit theme.

LPOVER the mgm't. unit map on the five quad road map. Specify 0 characters from the first map and the appropriate number for the second. Run on a three day weekend. Repeat the above two steps for each line theme.

The overlay operations will create many tiny polygons, especially if Merge rather than Dissolve was used. It is desirable to remove those polygons;

WINDOW the mgm't. unit map.

SIZE the vegetative cover map, for example, using 1 acre as the minimum size and, as maximum size, a number larger than the area of the largest polygon.

SAVE the map resulting from the size operation; that is the final vegetative cover map, we hope.

* * * * * * * * * * * * *

The next step is to prepare data for those who do Timber Management Planning. They want the vegetative cover map broken down into about 30 subcategories, such as:

Pure Pine site quality 3
Pure Pine site quality 4
Pure Pine site quality 5
Pure Pine site quality 6
Pure Spruce site quality 3
etc.

We do that in batch in MOSS using the SELECT command with the FROM option;

```
SED SELEMAPS
MAVALLTTY
STOP

SED SELEFROM
CLIFF
OPEN APACHE
SELECT FROM
SELEMAPS
PUREP3
SELECT FROM
```

SELEMAPS
PUREP4
etc.
ACTIVE
BYE

QBATCH/I
MOSS.BATCH APACHE
SELEFROM
)

We then MERGE those 30-40 subcategories into the 8 groups that the rest of the project is interested in.

All of the above data is considered tentative at this point, because experience has shown that the Overlay command sometimes produces strange results. So we make a graphic of those 8 groups. If there are no overlaps or gaps on that graphic, then we feel secure in proceeding onward.

* * * * * * * * * * * *

I will point out a few tricks we have learned in using the Hewlett command in MOSS.

The command accepts and uses correctly pen numbers 1-8.

It always uses pen #1 in the attribute option.

If the units of measurement are Feet, then the default increment length is correct, and the 3 Bar scale divisions are 2000, 2000, and 4000.

The dashed shading doesn't work.

The legend sometimes plots over the annotation space, for some critical size of map. Usually correctable by entering the legend on the lower part of the screen when using the Utility 8 command. I haven't researched this sufficiently to predict the occurrence of the overprinting.

The greatest waste of time was in learning what entries to use for "Distance between Pinch Wheels" when using the Rotate feature of the HP7585 and when a map would <u>just</u> fit 34" x 44" paper if it were properly centered. <u>When</u> using the Rotate button the distance between pinch wheel entry is nominally 44",rather than the normal 34". It happened that our very first project map would barely fit the 34" dimension (with the Expand pin on the back of the plotter ON) if it were properly centered. After much experimentation we found that entering 42" for the distance between pinch wheels

'fooled' the software and/or machine into centering the map, with about 1/4" to spare. Unfortunately, several of our timber management unit maps fit 34" x 44" paper only by manipulating the pinch wheel entry, which involves considerable time in experimentation.

* * * * * * * * * * * * *

The most devious of our procedures involved the buffering of streams and roads, and the subsequent determination of the acreage of commercial timber in those buffers;

SELECT using the Subject option, the Perennial streams from the stream map. In our case the subject string was PS!PERSTR.

WINDOW the timber management unit map.

BUFFER the perennial stream map.

.3079 <> (1/2 the total 400' buffer, in miles.)

No <> to resolve overlaps since it doesn't work, which is why the rest of the procedure is in MAPS.

WINDOW the timber management unit map, in MAPS.

RASTERIZE the buffer map, TYPE 7, HEIGHT 30 WIDTH 30.

RASTERIZE the commercial timber map, as above.

WINDOW the timber management unit map

INTERSECT the rasterized buffer map with the rasterized commercial timber map. The resulting map is a map of the commercial timber within the buffer. The acreage of that timber is quickly gotten with the AREA command, using the Totaling option.

It is not practical to sort the results of the Intersect command into subcategories, such as timber species. Since we usually do need output by species, it is necessary to do the sorting in MOSS, prior to entry into MAPS, as shown below.

* * * * * * * * * * * * *

To determine the acreage of commercial timber, by species, on soils that should be logged only when dry or frozen;

SELECT, using the `subject` option, the pertinent soils from the soils map previously made, entering

03E!22E!35E!41E!55B as the search string.

WINDOW the timber mgm't. unit map, in MAPS

RASTERIZE the new soils map and maps previously made in MOSS of Pure Pine, Pure Spruce, Pure Aspen, and Mixed Conifers, using the same cell format as before; Type 7 HEIGHT 30 WIDTH 30.

WINDOW the timber mgm't. unit map

INTERSECT each of the species maps with the soils map, separately, and get acreages of all. Very time consuming process. Keep reminding yourself that this operation is practically impossible to do manually.

* * * * * * * * * * * * * * *

One of the final steps is to produce a map showing the commercial timber, by species, that is <u>not</u> involved in any of the various restrictions. The need for this type of analysis is the main reason for the use of MAPS.

WINDOW the timber mgm't unit map

COVER the commericial timber map of Pure Pine with each map containing restrictions. The command looks like;

```
COVER RMAVPP WITH RMAVSLSDF WITH RMAVLAKBUF WITH
RMAVSTRBUF WITH RMAVGRBUF WITH RMAVELKCAF WITH ,
, RMAVCABLE WITH RMAVCAMBUF WITH RMAV.....
```

Repeat the Cover command for each species of timber.

CONCLUSION

The GIS has proven to be an effective tool for portraying and analyzing natural resource information on the Fort Apache Indian Reservation.

As MOSS is enhanced to provide faster processing times, and the defective commands are improved, we anticipate an integration of GIS into all aspects of natural resource management, with a substantial increase in our ability to manage those resources to the satisfaction of the owner.

MISSION NEARLY IMPOSSIBLE

Building Multiple Attribute Tables on the Data General DG-20

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This paper describes how multiple attribute may be entered on a personal computer (PC) using a data base management system (DBMS) and added to MOSS.

Resource managers think in terms of multiple attribute. For example, a soil scientist is not interested in just the soil type but on its suitability for septic tanks, erosion potential, etc. For a geographic information system to be useful, it must be able to describe spatial data by a multiple of attributes.

MOSS Commands to add multiple attributes to spatial data are ATTRIBUTE and ATTDES. ATTRIBUTE is the main multiple attribute support utility. This program allows entry of attributes either from the keyboard or a file. Keyboard entry of attributes is straight forward but is impractical when there are many features and/or attributes.

The more useful way of adding attributes is from a data file. ATTDES is the support utility for describing the structure of the data files. ATTRIBUTE and ATTDES require multiple attributes to be in an ASCII file with each variable in specific columns.

The Data General DG-20 does not have a DBMS available to easily create these data files. Attributes can be entered by typing each variable into a file, being careful to keep columns properly aligned; a tedious and confusing process. Data entry programs can be written to prompt for each variable and write it in the proper format to a file. GIS users generally are not programers; so this is not usually a viable alternative.

Functions in DBMS are data definition, entry, editing, listing, and import/export. These features allow for easy creation of multiple attributes. Programming ability is not required but a knowledge of the data. The field sheet provides the details on the data format.

The data base is created with fields named and formated as described on the field sheet. For example, if habitat type is recorded as a 3-digit number, a field named "habitat type", width 3, data type integer occurs in the DBMS. Data from field sheets are added to the data base. Most DBMS allow the use of a data-entry form that looks identical to the field sheet. This facilitates the entry of data and minimize errors.

MOSS requires each feature to have its own list of multiple attributes. If a subject occurs as several features, that record needs to duplicated for each. Additionally, the multiple attribute table needs to be in the same order as the subjects on the map. This can be done by adding an additional field in the DBMS called "subject order". The value of this field is the item number of the feature. The DBMS should be sorted by "subject order" before it is exported.

To use these data in MOSS, the data must be exported from the DBMS into an ASCII file. Most DBMS allow for the selection and reordering of attributes when data are exported. This new file should be exported in fixed record format. All attributes for a spatial feature comprise one line of data.

After creating the ASCII file, it must be transferred from the PC to the Data General. Several communication packages are available and I recommend selecting a program that preforms error checking. A useful file transfer program is Kermit; a public domain program distributed by Columbia University. Kermit is available for many micro and mainframe computers.

The multiple attributes are added to the MOSS map by first defining the format with ATTDES and adding them with ATTRIBUTE. A copy of the description of the DBMS'S fields, their data type and length provides the response to the prompts in ATTDES.

DISCUSSION

This procedure was developed because I could not find a DBMS for the Data General DG-20 computer. There are other reasons why this is a useful procedure, regardless the computer system running MOSS.

Data may already be available on PCs. For example, SCS developed a PC version of their Soils-5 database. DBMS programs are useful tools to reformat, select, and sort data downloaded from other computers. If data are in a tabular format, they can be directly added to a DBMS.

Once in the DBMS, the data may be manipulated as required by MOSS. For example, Canada Goose observations were on the University of Montana computer. These data were transferred with Kermit to a PC, added to a DBMS, exported as point data for XYSUBJECT and as multiple attributes for ATTDES and ATTRIBUTE.

Building multiple attributes can save money at data entry and make feature selection easier for the MOSS user. For example, digitizing timber types for the Colville Indian Reservation was estimated to cost $40,000 using a complicated subject label. The estimate using a multiple attribute file already available on a PC was $25,000. Using multiple attributes not only saved $15,000 but made the selection of features easier. Features can now be selected simply by specifing variable name and value.

Building multiple attribute tables on a PC removes this processing and storage space from the GIS computer. On small systems and limited disk space, this advantage may overcome the nuisance of having the data on 2 computers.

Finally, having the multiple attributes in DBMS and MOSS provides added flexibility for reporting and analysis. DBMS are excellent for report preparation. Just as data may be exported and added to MOSS, data may be exported and used with a variety of application programs such as statistical packages and home range programs. By having the multiple attribute in the DBMS, the data may be analyzed by the most appropriate program.

DBMS have been a useful tool to create multiple attribute files. A knowledge of the field data is required, not the ability to write computer programs. This process does not depend on a specific program but can be done by any DBMS that exports files in tabular format.

PRODUCING LAND COVER MAPS SUITABLE FOR MOSS FROM MANUAL INTERPRETATION OF LANDSAT THEMATIC MAPPER IMAGERY

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ABSTRACT

The Bureau of Indian Affairs investigated manual mapping of vegetative land cover and initial soil mapping units as a technique to save time and money in the initial phases of a soil and range survey. Landsat V Thematic Mapper false color composites at 1:100,000 scale overlaid with mylar were interpretted by hand after a three level vegetation classification framework was established. This map was captured as a MOSS data theme. Estimated time and dollar savings are 66 to 75 and 33 to 70 percent respectively. Additionally, the project produced a data theme with many other uses and a hard copy record of large scale land use information for the San Carlos Indian Reservation on two June, 1985 dates.

INTRODUCTION

In 1970 Sapp et.al. strongly supported the use of remotely sensed products for analysis and evaluation of Interior Department resources. Haas (1986), Degloria and Colwell (1986) reinforced Sapp's affirmation, using data from the most recent U.S. Earth Resource Observing Satellites, the Landsat Thematic Mapper (TM) to map and monitor various land uses.

The Bureau of Indian Affairs (BIA) Phoenix Area (Arizona, Nevada, Utah and Southern California) is allocated three (3) cents per acre for range management by Congress. Comparatively, in the same region, the Forest Service is allocated 42 cents per acre, the Bureau of Land management 15 cents per acre, the National Park service 57 cents per acre. Each agency is responsible for conducting resource inventories, establishing carrying capacity for livestock and wildlife and monitoring forage utilization. Accomplishing these three functions within prescribed guidelines requires efficiency. The San Carlos Agency, Branch of Land Operations has investigated satellite imagery as a tool to develop an initial land cover map for a 230,000 acre area scheduled for a soil and range inventory.

In standard soil and vegetation surveys using nine by nine inch aerial photography, up to one-third of the survey time and expense is used to establish initial mapping unit polygons. Experience from other work suggested that TM imagery would provide a suitable base map to substitute for traditional techniques in a low intensity (Order III or IV) soil survey and mapping of plant community types.

TECHNIQUE

Two Landsat V TM 1:100,000 scale images were obtained to compare the effectiveness of various band combinations for mapping vegetation and soils. These false color images used bands 5,4 and 3, measuring reflectance in the mid infrared, near infared, and red spectral regions respectively; and bands 4,3 and 2, measuring reflectance in the near infrared, red and green regions respectively. Previous efforts at mapping soils and most other resource mapping applications, have focused on computer processing Landsat digital data (DeGloria et al. 1986, Haas 1986, Roudabush et. al. 1985). In this effort work was designed to develop a technique permitting a field technician to use the false color images for manual interpretation of resource types.

A modified Anderson three level land use/land cover classification framework was developed as discussed by Haas (1986) with Level I identifying the land use/land cover classes at a general level from which levels II and III could be developed. Level II, the natural terrestrial vegetation physiognomic classification, was determined by aerial coverage and height of the vegetative component. Level III, the plant community type was identified by the names of the primary or the primary and secondarily dominant plants of an identified vegetative community (Table 1). The framework is used to identify plant communities and name them as field data is collected.

Base mapping is essential for scaling TM products and locating political boundaries on polyester drafting film (mylar) worksheets. The USGS 1:100,000 scale land ownership series was selected in this instance because coverage is available for most of the nation, it is an accurate stable base for data capture, and the use of TM imagery at 1:100,000 scale is optimal. A sheet of mylar was first laid over the USGS map. Latitude and longitude grid tic marks were transferred for later use in digital data capture. Significant cultural features; highways, stock watering ponds, a dam and reservoir were used to identify reference areas. These and the reservation boundaries were transferred to the mylar land use/land cover base map.

The mylar base map was then overlaid on the TM image and the cultural features registered. More bodies of water, riparian zones and very large readily apparent landscape units were mapped first. The mapping following was more detailed using a 290 hectare (640 acre) minimum mapping unit area.

Upon completion of mapping, a film positive of the mylar was made to be used for the digital capture stage. This product was later used as an overlay for collecting field ground-truthing. Initial digitizing was done on a Hewlett Packard using IDIMS/GES to produce field maps plotted at 1:100,000 to assist in ground-truthing. Ground truthing edits were made on the plotted hard copy. Plots were also made at 1:62,500 and 1:24,000 scales to check mapping accuracy with contour lines and perform detailed ground-truth edits. All final plotting of the mapping data has been made on AMS and the final products are satisfactory.

TABLE 1: An example of a modified Anderson three level land use/land cover classification framework

BIA VEGETATION CLASSIFICATION FRAMEWORK
11/10/86

LEVEL I	LEVEL II	LEVEL III
1. URBAN		
2. AGRICULTURE	2A IRRIGATED AG	
	2B DRYLAND AG	
3. NATURAL TERRESTRIAL VEG.	3A FOREST	3A1 PONDEROSA PINE
		3A2 DOUGLAS FIR
		3A3 PINYON
		3A4 MIXED FOREST
	3B WOODLAND	3B1 PINE/JUNIPER
		3B2 JUNIPER/PINE
		3B3 MESQUITE
		3B4 OAK
		3B5 PINYON
	3C WOODLAND/SHRUB	3C1 JUNIPER/SCRUB OAK
		3C2 JUNIPER/MESQUITE
		3C3 PINYON/SCRUB OAK
		3C4 PINYON/MESQUITE
		3C5 PINYON/MIXED SHRUB
		3C6 JUNIPER/MIXED SHRUB
	3D SHRUB/WOODLAND	3D1 SCRUB OAK/JUNIPER
		3D2 SCRUB OAK/PINYON
		3D3 MANZANITA/JUNIPER
		3D4 MANZANITA/PINYON
	3E SAVANNAH	3E1 JUNIPER/MIXED GRASS
	3F SHRUBLAND	3F1 MIXED CHAPPARAL
		3F2 CEONOTHUS
		3F3 SCRUB OAK
		3F4 ACACIA
		3F5 MANZANITA
		3F6 JOJOBA
		3F7 PALOVERDE
		3F8 CREOSOTE
		3F9 CREOSOTE/ACACIA
		3F10 MTN MAHOGANY/BUCKBRUSH
		3F11 PALOVERDE/JOJOBA
		3F12 PALOVERDE/CHOLIA
	3G SHRUB/HERB	3G1 MESQUITE/MIXED GRASS
		3G2 JUNIPER/MIXED GRASS
		3G3 SCRUB OAK/MIXED GRASS
		3G4 CEONOTHUS/MIXED GRASS
		3G5 ACACIA/MIXED GRASS
		3G6 MIXED SHRUB/MIXED GRASS
	3H LOW SHRUB	3H1 SNAKEWEED
		3H2 BUCKWHEAT
		3H3 BUCKWHEAT/PALOVERDE
	3I LOW SHRUB/HERBACEOUS	3I1 SNAKEWEED/BLACK GRAMMA
	3J HERBACEOUS	3J1 GRASSLAND - WARM SEASON
		3J2 GRASSLAND - COOL SEASON
		3J3 ANNUAL GRASS
		3J4 GRASS/MIXED SHRUB
	3K LOW COVER	3K1 CREOSOTE
		3K2 JUNIPER
4. WETLAND	4A WOODED	4A1 SALT CEDAR
		4A2 MESQUITE
		4A3 CREOSOTE/MESQUITE/WILLOW
	4B NON-WOODED/HERBACEOUS	4B1 BERMUDA GRASS
5. WATER	5A STREAMS/CANALS	
	5B LAKES	
	5C RESERVOIRS	
	5D BAYS/ESTUARIES	
6. BARREN	6A DRY SALT FLAT	
	6B BEACHES	
	6C SANDY/NOT BEACH	
	6D BARE EXPOSED ROCK	
	6E STRIP MINES, QUARRIES AND GRAVEL PITS	
	6F TRANSITIONAL AREAS	
	6G MIXED BARREN LAND	
7. PERENNIAL ICE & SNOW	7A PERENNIAL SNOWFIELDS	
	7B GLACIERS	
8. SHADOW & UNKNOWN		

DISCUSSION

Initial Level II land cover interpretation of the 104,545 hectare (230,000 acre) area was completed in eight hours, field evaluation took 16 hours, refined image interpretation is expected to take eight hours. An additional 714,000 hectares (1.57 million acres) have been mapped in 17 hours, with polygon labeling expected to take four hours. 28,213 hectares (62,069 acres) were mapped and labeled per hour. A soil scientist has estimated that mapping the San Carlos Reservation's 818,200 hectare (1.8 million acres) on 1:24,000 orthophoto quads would take 92 hours at a mapping rate of 8,893 hectares (19,565 acres) per hour.

Comparative costs for initial land cover/land use mapping are shown in Table 2 below using the 818,200 hectare (1.8 million acre) San Carlos Reservation as a sample case:

Table 2: Cost comparisons for various land cover mapping techniques on the million acre San Carlos Apache Reservation

TYPE OF IMAGERY	LANDSAT TM 1:100,000		ORTHOPHOTO 1:24,000		COLOR AERIAL PHOTO 1:15840	
IMAGE ACQUISITION COSTS		$1750		$3240	(1981) - $7852	
Mapping Costs, Land Cover/Soils						
Mapping Hours	29		92		110	
Cost/Hour		$12		$12		$12
Digitizing Hr	84		---		---	
Cost/Hour		$10		---		---
$ Total Mapping		$1188		$1104		$1320
PROJECT COST		$2938		$4344		$9172
COSTS/ACRE		$.0016		$.0024		$.00509

A comparison of acquisition costs of TM, orthophoto and color aerial imagery shows a two to four fold difference in cost. Mapping hours vary from 66% to 75% less time than those of traditional procedures. Using orthophoto and color photography the data capture stage would come at a later point of the inventory process. The TM mapping and data capture was 33 percent less than the opthophoto mapping. TM was 69 percent less than color aerial photo technique. As mentioned above, a significant cost factor in the TM cost per acre is digitizing expense, not incurred in this instance for the other two data sources.

Ground truthing of the office generated map showed two areas needing editing. Ecotones, blending of vegetative types as elevation, precipitation and aspect change, proved difficult to office map. Editing was also needed in one 2300 hectare (5,000 acre) area of water flowing over bare rock surrounded by bare rock outcrops.

When the 1:100,000 product was plotted on mylar and overlaid on a 7.5 minute quad, accuracy with contours and the green forest vegetation areas was estimated to be greater than 90%, producing a satisfactory product for a field crew to refine as the survey continues.

CONCLUSION

At Order IV this technique provides a fast, accurate method for developing initial land cover/land use information. The end product is a MOSS GIS data theme rather than a hard copy product needing to be captured. When the mapping is completed, technical staff are left with a hard copy image that can be used to map grazing utilization, delineating geologic structures, provide a June, 1985 point-in-time record for large scale land use activities and be used for other interpretive activities.

Future uses for this data theme at San Carlos include prescription burn fuel type maps, vegetation trends, firewood cutting locations, water sources for livestock and wildlife, habitat types for big game, potential sites for rare and endangered plant species, probable locations of cattle for aerial stock counts, probable locations for existing big game species as well as potential sites for big game plantings to name several future uses.

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Software Development Session

Section 7

CURRENT STATUS OF PC-MOSS

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ABSTRACT

The development of high performance, cost effective personal microcomputers has permitted the application of low cost hardware in the area of Geographic Information System (GIS) analysis. The Map Overlay and Statistical System (MOSS) is one example of an existing GIS system with a large user base which has been ported to a IBM compatible, Personal Computer (PC) Disk Operating System (DOS) environment. The result is a tremendous potential for inexpensive distributed GIS processing to be implemented in organizations already using GIS technology or for the introduction of GIS technology to organizations which previously have not been able to afford such technology. These developments have stimulated much interest. This paper draws upon recent experiences in the development and testing of PC-MOSS to describe the current status of MOSS in the PC environment. Minimum system hardware requirements are described as well as high-end maximum performance systems. The current status of individual commands is discussed, detailing what potential users can expect from MOSS as a GIS analysis tool in the PC environment. Potential future developments are described as they relate to increased functionality of the PC-MOSS system. Future systems and configurations are addressed in light of current developments in PC hardware and software. The paper is accompanied by a demonstration of PC-MOSS on a high performance DOS workstation which exhibits the functionality of the system and provides a first hand look at its use.

INTRODUCTION

Recent developments in PC technology have addressed the serious limitations to technical work once inherent in small, inexpensive, single user computer systems. Furthermore, the trend shows no sign of ending. PCs continue to get faster, provide greater storage capacity, and interface with more inexpensive, high quality graphics peripheral devices.

The Bureau of Land Managements (BLM) Denver Service Center (DSC) is currently developing a PC based version of MOSS in response to a need expressed by the U.S. Army Corp of Engineers. Current technology for single user computers permits cost effective access to GIS technology in organizations which previously might not have justified the cost of a GIS approach. In addition, the use of inexpensive technology may prove useful as front-end workstations in organizations which operate minicomputer based GIS.

HARDWARE DEVELOPMENTS

The PC was once a relatively expensive, slow and technically limited computer. Largely used for office automation tasks and only the simplest of technical data processing, it became a popular means of addressing those needs. The original PCs had little to offer in the area of graphics capabilities. Technical work was seldom performed on these computers because of their relatively slow processing speeds, the lack of large data storage devices, and the lack of professional quality FORTRAN 77 compilers.

In recent years all of these limitations have been addressed. The original PC which used a processor speed of 4.66 megahertz has given rise to 32 bit processors running at speeds of up to 16 megahertz. DOS has remained the operating system under which all of these computers have run, thus providing upward compatibility. Large data storage devices are now routinely used with PCs. Fixed disk drives, once commonly seen with capacities of 10 and 20 megabytes, are now often as large as 40 megabytes. Third party hardware vendors can supply fixed disks up to several hundred megabytes in size and optical storage devices are now available which can exceed that capacity.

Porting MOSS to the PC-DOS environment has become possible because of these and other developments. Interest in converting MOSS to a FORTRAN 77 standard set of code has also facilitated the movement of MOSS code to PCs. The result is an opportunity, evidenced by this first effort to move MOSS to the PC, to provide GIS technology on the most widely used, mass production processors available to date. This will make GIS technology available to many who previously could not afford it.

The developments which have made this work possible are not over. There continues to be profound changes in what technical users expect of PCs and vendors continue to respond with ever increasing performance and data storage capacities. The future looks promising for those interested in performing GIS processing in a single user workstation environment.

HARDWARE REQUIREMENTS

Although running PC-MOSS requires a PC hardware configuration beyond that typically used for office automation, the requirements are similar to that used in many technical fields using PC technology.

The minimum hardware configuration for PC-MOSS is as follows:

IBM compatible PC/XT
640 kb Memory
XXX87 Math Coprocessor
360 kb Floppy disk drive
20 mb fixed disk
600 X 200 graphics card and monitor (color or mono)

In the interest of increased processing speeds and higher quality graphics a preferred hardware configuration is as follows:

IBM compatible PC/AT (8 MHz or faster)
640 kb Memory
XXX87 Math Coprocessor
1.2 mb Floppy disk drive
40 mb fixed disk
750 X 350 Hercules compatible card and monochrome monitor

The executables for PC-MOSS occupy approximately 5 mb of fixed disk space. Users of PC-MOSS should give due consideration to their data space requirements before deciding on an appropriate fixed disk capacity.

Beyond this configuration there is much that can be done to further enhance the performance of PC-MOSS. Use of higher performance PCs can result in significant reductions in processing times for many tasks. PC-MOSS has been successfully run on IBM PC/AT compatibles running at speeds up to 12 MHz and there is no indication that it would not run successfully at 16 MHz.

SOFTWARE REQUIREMENTS

In addition to an appropriate version of DOS, running PC-MOSS requires a Tektronix graphics terminal compatible device driver for the PC. Such software interprets all instructions being written to the PC console. When these instructions can be interpreted as Tektronix instructions, the console is put into Tektronix graphics terminal emulation mode. Tektronix PLOT10 instructions are correctly interpreted and the appropriate vectors drawn on the console screen. Use of such software enables MOSS software to be moved to the PC environment without changes to the graphics output routines. This simplifies the conversion process and minimizes changes required to the minicomputer versions, thus simplifying the task of software maintenance on a variety of computer architectures.

CURRENT CAPABILITIES

The original intention of PC-MOSS was to provide a subset of the MOSS vector processing commands in the PC environment. PC-MOSS offers a subset (approximately 40) of the MOSS vector data processing commands users are familiar with from the Data General environment. These are the only capabilities available at this time. There is no digitizing, projection, raster processing or cartographic output capabilities available at this time as part of PC-MOSS.

The following specific MOSS vector data processing commands are currently available in PC-MOSS:

PC-MOSS COMMANDS

ACTIVE	AREA	ATTRIBUTE	ATTDESCR	AUDIT
BSEARCH	BUFFER	COMPUTE	DATABTEST	DELETE
DEVICE	DISTANCE	ERASE	EXIT	FREE
FREQUENCY	GENERATE	IMPORT	HELP	LEGEND
LENGTH	LIST	LPOVER	MERGE	NUMBER
OPEN	OVERLAY	OVERLAP	PERIMETER	PLOT
PROXIMITY	QUERY	REPORT	RESET	SAVE
SELECT	SHADE	SIZE	STATUS	SUB2AT
SUBEDIT	WINDOW	ZOOM		

Although this list provides only a small subset of the MOSS capabilities users have become accustomed to, the level of interest in PC-MOSS is high. If PC-MOSS becomes widely used it is likely that some users will pool resources to develop more capabilities as well as a public domain system for digitizing and for cartographic output. Such a system might be based upon existing minicomputer software such as the Automated Digitizing System (ADS), Analytical Mapping System (AMS), and Cartographic Output System (COS).

PERIPHERAL SUPPORT AND INTERFACES

At this time the only peripheral support provided by PC-MOSS is printer and graphics peripheral support provided by the Tektronix device driver software. Some such software will support dot matrix printers as graphics devices; others will also support desktop plotters. All graphical output from PC-MOSS at this time is in the form of screen dumps from the console screen.

The lack of a direct capability for map digitizing, projection changes, and cartographic output constitutes a major drawback to the use of PC-MOSS. The MOSS IMPORT command provides one mechanism for entering map data into PC-MOSS. Data from other PC based digitizing programs could be converted to the MOSS IMPORT format for use in MOSS. An interface to a scan digitizing capability has been described elsewhere (Maslanik and Szajgin). Any data transfer capability between a minicomputer running MOSS and a PC running PC-MOSS would permit transfer via the IMPORT format. A tape driver interface for the PC or a serial communications link would provide the necessary capability. Unfortunately, the MOSS EXPORT command is not available in PC MOSS. This precludes such a simple approach to moving MOSS data into other PC systems (such as CAD systems) for cartographic output. At this time, such and undertaking requires converting the MOSS data directly into a format usable by the target system. The map projection software is also not available in PC-MOSS. This limits PC-MOSS in the area of cartographic manipulations. Future developments may address these shortcomings.

PROGRAMMING ENVIRONMENT

PC-MOSS was developed using IBM Professional FORTRAN 77 (Ryan-McFarland FORTRAN 77). This compiler offers the features to make porting from the minicomputer environment possible. The compiler requires use of an XXX87 math coprocessor. The GIS front-end/user-interface is written in Microsoft FORTRAN rather than IBM Professional FORTRAN 77. This permitted the development of individual PC-MOSS commands as separate executables which can be spawned processes from the Microsoft FORTRAN driver. This has advantages from both the developmental and applications perspectives of PC-MOSS.

A set of software tools for use in the development and maintenance of PC-MOSS was also developed. These tools consist of DOS .BAT command files which simplify the tasks frequently done during software development. Two major areas in which these tools are used is in file management and in the compilation and linking process. Such simple tools greatly assist the programmer in the accomplishment of routine tasks. In addition, another software tool provides information regarding the dependencies among the various MOSS software modules. This information makes the compilation and linking processes easier to manage.

USER ENVIRONMENT

The PC-MOSS directory structure differs from the Data General MOSS directory structure. PC-MOSS can be executed with no master directory. PC-MOSS creates a separate .DT file for each project (PROJECTNAME.DT). The POLYGON.DT file is no longer used. The user creates a new project by executing the OPEN command within PC-MOSS. The OPEN command then prompts for a project name. To create a project catalog (PROJECTNAME.DT), the OPEN command should be used immediately upon creating a new PC-MOSS directory.

When a project name is specified using the OPEN command, that project remains active after leaving PC-MOSS. When MOSS is executed again, the last project OPENed becomes the current project. Thus the Data General MOSS RESTART command no longer applies. By default, PC-MOSS is always invoked in RESTART mode. The user changes projects by using the OPEN command or by placing a valid project name as the first parameter of a new command line.

If a master directory is used for a project, it must reside in a DOS directory of the same name as the project. A master directory must contain only one .DT file called MASTER.DT. PC-MOSS also retains the name of the directory which holds .DT files. This difference permits PC-MOSS to distinguish between master and work directories. Master and work directories must be immediately below the system (DOS) root (/) directory.

The directory structure used for PC-MOSS is described as follows:

PC-MOSS DIRECTORY STRUCTURE

DIRECTORY NAME	DIRECTORY CONTENTS
/GIS	The PC-MOSS system
/GIS/SRC	Final FORTRAN 77 Source Code
/GIS/OBJ	Object Modules
/GIS/EXE	Executable Modules
/GIS/LNK	Link Modules
/GIS/UTL	Utility Command Files
/GIS/LST	Compiler Listings
/GIS/TEST	Test Data Files and .DT Files
/GIS/TEK	Tektronix Routines
/GIS/DEV	Developmental Source Code
/GIS/HELP	User Help Files
/GIS/INTRFACE	User Interface Routines

BETA TESTING

PC-MOSS is currently undergoing Beta testing. Approximately ten sites were chosen to test the software prior to general release. It appears that the PC-MOSS software is performing well although some problems remain. A small applications project is scheduled as a realistic test for the software.

Some problems have been encountered with the use of PC-MOSS on certain IBM PC-AT compatible computers, particularly high-performance models which run at higher processing speeds. These problems appear to be related to the Tektronix graphics terminal device driver used and do not appear to be problems with PC-MOSS itself. Examples of the type of problem observed include the computer "hanging" when the end of a screen of text is reached in the MOSS session and non-functioning cursor keys. It is not known if these problems are related to the processor speeds, memory conflicts, or some other source. They can most likely be avoided by not using the particular computers on which they occur or by using another Tektronix graphics terminal device driver.

HIGH-END SYSTEMS

In addition to the minimum and suggested requirements for hardware described above, some users may have a need to perform a high proportion of sophisticated analysis using PC-MOSS. This may be a potential problem due to excessive processing times. Furthermore, for large applications the minimum requirements will not provide sufficient data storage space.

PC technology has developed into a market place in it's own right. Compatible and third party vendors are competing to claim their share of a large demand. A principal area of competition is that of performance. Recent distribution of PCs using the Intel 80386 processor running at a speed of 16 MHz is one example. These processing speeds are paralleled by large increases in data storage capacity and access speeds. Much of the work performed during the final stages of PC-MOSS development and testing were performed on high performance PCs running at speeds of up to 12 MHz.

Use of these high-performance PCs with large data storage capacities, high-resolution graphics, cost effective graphics peripherals (not currently supported), minicomputer communications, and a tape drive interface can provide a convenient and powerful single user MOSS workstation. The possibilities will only increase as PCs get more powerful.

DISTRIBUTION OF PC-MOSS

Although it is not currently being distributed, PC-MOSS should be generally available in the near future. Current plans include further testing by BLM and the addition of MOSS raster data processing capabilities. As with other versions of MOSS, distribution of PC-MOSS will be conducted through BLM-DSC.

PC-MOSS will be distributed with an installation program which prompts the user for diskettes by number. On 360k diskettes PC-MOSS is distributed on approximately 19 sequentially numbered diskettes. On 1.2m diskettes PC-MOSS is distributed on approximately 7 sequentially numbered diskettes.

The software is supported by user documentation which details the differences between PC-MOSS and Data General MOSS, and programmer documentation which describes the PC-MOSS installation procedures and programming environment.

FUTURE DEVELOPMENTS

In the short term more capabilities will be added to PC-MOSS. Immediate plans for PC-MOSS include further testing by BLM and the initiation of a porting/development effort for the raster processing commands.

Work is currently underway to interface PC-MOSS with a scan digitizing system (Maslanik and Szajgin). For some applications this will permit a cost effective alternative to manual digitizing of map data. Furthermore, use of the MOSS IMPORT file format can facilitate ready transfer of data from a number of PC digitizing programs.

Some limited work has been done to assess the utility of PC based Computer Aided Design (CAD) systems for use in the cartographic output effort of a GIS project. This appears promising as a capability which could be interfaced with PC-MOSS.

The PC CAD market continues to drive prices down on high quality graphics peripherals. PC CAD users cannot justify purchasing peripherals which cost more than the computer which drives them. For this reason, peripherals manufacturers have begun offering inexpensive digitizing tablets, pen plotters and other devices which have wide application in GIS processing. GIS applications will obviously benefit from these developments.

PC-DOS computers continue to achieve greater levels of performance. For single user workstations, some PCs can rival traditional minicomputers for some tasks. More increases in performance are expected, both at the hardware level and at the operating system and compiler levels.

In the medium to long term, PC-MOSS can be expected to provide the kind of processing capabilities once only available on much larger and more expensive computers. PCs, graphics peripherals, and compilers will add to major increases in both functionality and performance.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. David Culley of TGS Technology, Inc., principal developer of PC-MOSS, and Ms. Carol Wilson of the Bureau of Land Management, principal tester of PC-MOSS, for their assistance.

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IMPORT OF SCAN DIGITIZED DATA INTO PC-MOSS: A CASE STUDY

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ABSTRACT

A major cost associated with computer processing of spatial data using Geographic Information Systems (GIS) is the initial expense of manual digitizing. For several years, scan digitizing has been under investigation by numerous organizations as a cost effective alternative to the manual digitizing process. This paper documents the steps required to transfer data digitized using an operational scan digitizing system into the Personal Computer (PC) - Map Overlay and Statistical System (MOSS). The processing required to preview the scan-digitized data and to re-format the data into standard MOSS IMPORT files is discussed. The scan-digitized information, consisting of line and point data, was successfully entered into PC-MOSS and manipulated using standard MOSS functions. Processing speed and storage of the PC system are adequate for operational transfer of scan-digitized data into PC-MOSS. Additional work is required to develop a more sophisticated scheme to retrieve polygons from the existing line-and-point data structure produced by the scan-digitizing system.

INTRODUCTION

Geographic Information Systems (GIS) provide an efficient method of manipulating map information. Whether or not a GIS is implemented, however, often depends on the resources available for map digitizing and editing. In an attempt to reduce the cost and time required to digitize maps, various methods of automated data capture have been investigated. Principal among these methods are automated line-following devices and scan-digitizing systems. Recent improvements in scan-digitizing technology, such as linear array digital cameras and more effective line-following software, suggest that scan digitizing systems may provide an alternative to manual data capture for some applications (Fain, 1985). The objective of this paper is to describe the development of a software interface between the Personal Computer (PC) - Map Overlay and Statistical System (MOSS) and map data captured using a commercial scan-digitizing system, and to discuss the limitations of this approach.

SCAN-DIGITIZING SYSTEM

The sample data set used for this project was supplied by Energy Images, Inc., Boulder, Colorado[1]. These data were captured by Energy Images, Inc. using their commercially-available SmartScan™ system. The SmartScan system operates by converting a raster image of a map (recorded using a linear-area camera) to multiple themes of vector information. The conversion process is primarily a software task, with an operator present to oversee the line-following and data editing procedure (Energy Images, 1985). The quoted cost and time required to capture essentially all themes except contours from a typical U.S.G.S. 7.5 minute quadrangle using the Smartscan system is about $200.00 and 1.5 hours. A detailed discussion of the SmartScan system, as well as a review of other scan-digitizing systems in the market, is beyond the scope of this paper.

SAMPLE DATA SET

The sample data set supplied by Energy Images, Inc. consists of the major themes present on the 15-minute Cape Mendocino, California U.S.G.S. quadrangle (Fig. 1). The features captured include coastline, major rivers and streams, primary and secondary roads, offshore breaks and rocks, triangulation stations, landnet, political boundaries, and labels. Coordinates are given in fractions of latitude and longitude.

The SmartScan data set used consists of a file of 80 character records, with one record per coordinate. Each record contains a 20-character attribute, several identification codes, and the Latitude/Longitude location of the point. Records for line data are grouped as "line segments"; each set of coordinates corresponding to a segment are labelled with an identifier code. The number of coordinates per segment, as well as the sequence number of an individual coordinate within a segment, are stored in each data record. The data set used is therefore in neither an arc-node nor "spaghetti" structure. Instead, the file structure contains some arc information, but does not record locations of nodes.

According to recent discussions with Energy Images, Inc., the SmartScan system does not have the ability to identify and build polygons. All features in the sample data set are recorded as either line or point data. Polygon-type features in the data file, such as the boundary of a Coast Guard station and the outlines of offshore rocks, are represented by a closed stream of line coordinates. With the exception of one case, the first and last coordinates of the data set for all polygonal features checked are identical. In a single case where a boundary is shared between features, the points making up the shared segment in each feature are the same, and the segment is identified as a unique set in each coordinate stream. Table 1 lists the number of points contained in the sample data file for the major features digitized. Table 1 also

---

1 Reference to a particular product or company does not necessarily constitute an endorsement.

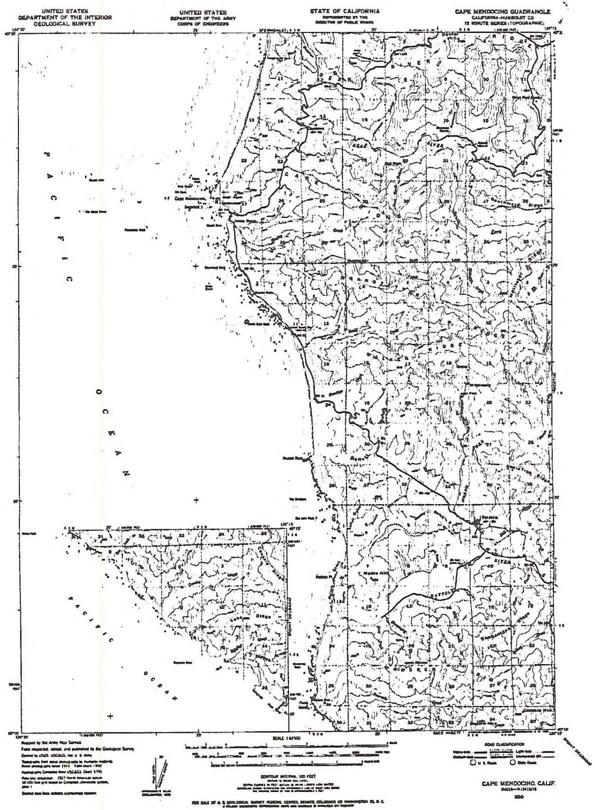


Fig. 1. Cape Mendocino 15' U.S.G.S. quadrangle from which scan-digitized data were captured.

includes estimates of time required for manual digitizing of the themes listed. These digitizing times were based on the Analytical Mapping System (AMS), and were calculated using a regression procedure to predict digitizing times as a function of map complexity (Getter et al., 1986).

TABLE 1. Number of points per feature in scan-digitized file, and estimated time required for manual digitizing.

Hydrography	7774 points	(4.5 hrs.)
Roads	2285 points	(2.5 hrs.)
Coastline	1611 points	(1.0 hr.)
Land Net	654 points	(2.0 hrs.)
Labels	491 points	(2.5 hrs.)
Offshore Features	333 points	(2.5 hrs.)
Boundaries	95 points	(1.0 hr.)

The amount of detail captured for a given line in the scan-digitized file appears to be quite high, yielding a considerably greater number of coordinates than would be captured using a manual method. For example, the first two bends in the Bear River east of the river's mouth (a map distance of about 0.15 inches) is digitized using a total of 20 coordinates. The average movement between coordinates for these 20 points are 0.006 inches and 0.005 inches in the X and Y directions, respectively. Since the times quoted above for manual digitizing are based in part on the number of coordinates given in the scan-digitized file, actual digitizing times using a cursor and tablet would probably be less than those shown. On the other hand, the precision of the scan-digitizing system permits a more accurate representation of the original map. This precision, and the associated speed of the automated line-following software, should be particularly valuable for maps containing numerous complex polygons. Additional study, such as that described by Jenks (1979), is needed to determine the most desirable precision of the scanning system for typical mapping applications. For some uses, such as plotting at a small scale, it may be worthwhile to pass the data through a distance-filtering routine to remove points with distances of travel below a given tolerance.

MOSS IMPORT FILE FORMAT

The principal method of entering map data into MOSS and PC-MOSS is via the MOSS IMPORT function. The IMPORT function translates coordinate and attribute data into MOSS file format, and builds the necessary header and data structure to permit analysis using other MOSS functions. The IMPORT function expects input files to be in a specific format (referred to as IMPORT or ADDWAMS format), with separate files for point, line, and polygon data. IMPORT files consist of attribute records and coordinate records. Each item (or feature) is represented by one attribute record, and N coordinate records, where N represents the number of points used to define the item. The coordinate count N is stored in the attribute record, which also contains a number assigned to

the item during the IMPORT file formation process, and an attribute field. Island polygons in IMPORT polygon files are identified by keys contained in coordinate records. Coordinates in the IMPORT file can be in either latitude/longitude or (Universal Transverse Mercator) UTM units.

Based on this brief description of the file structures of SmartScan files and MOSS IMPORT files, it can be seen that the scan-digitized data contain all the necessary information, including attributes, coordinate counts, and coordinates, to build point and line IMPORT files. Although the scan-digitized files do not specifically identify polygons, the fact that first and last coordinates are repeated for polygonal features provides a means of separating out these features into a polygon IMPORT file. Unfortunately, the scan-digitized file provides no simple method of identifying island polygons.

SOFTWARE REQUIREMENTS

A goal of this work was to develop a conversion scheme adequate for operational needs, e.g., the conversion should be a fairly rapid process given the type of equipment available. In addition, data reformatting must require a minimum of human interaction.

With these restrictions in mind, Fortran 77 modules were developed to perform the necessary conversions in file structure and format. All programs were written using standard Fortran 77 conventions, and were successfully compiled and linked using both Microsoft Fortran Version 4.0 and IBM Professional Fortran.

Processing consists of two main steps. In the first step, the single SmartScan file is broken up into separate point, line, and label (text) files. During this stage, the data are translated to IMPORT format, with one attribute record per segment, and N coordinate records per segment. The second processing step divides each IMPORT file into separate themes (such as political boundaries, roads, hydography, etc.) by comparing attribute codes to a table prepared by the operator using an interactive program. This step essentially duplicates the action of the MOSS SELECT function, but provides some useful capabilities outside of MOSS.

In addition to these key tasks, existing programs were used to translate the original latitude/longitude coordinates into UTM meters and map inches. As a means of previewing the IMPORT files before entry into PC-MOSS, a relatively simple color graphics program was developed to take advantage of the display capabilities of the PC workstation. This Fortran program is linked with a library of graphics routines (Enhanced Graphics System™ by Filtrex Research, Inc.) containing display drivers for Hercules and EGA graphics devices. UTM or map inch data can be overlayed and displayed in various scales and in several colors using this software. In addition, data files can be plotted on a Hewlett Packard (HP)-compatible Epson pen plotter using Fortran plotting routines incorporating HP Graphics Language plot calls.

RESULTS: CONVERSION TO IMPORT FILES

The computer system used for all software development and analysis is described in Table 2. In order to compare processing times with various system configurations, several processing steps were timed with the PC set at a processing speed of 6 MHz, then at 12 MHz. Several steps were also timed using reads and writes to different devices. These times are summarized in Table 3.

Table 2. Microcomputer Work Station

Computer - - -	PC's Limited™ 286-12 personal computer. 40 MB hard disk, 1.2 MB and 360 KB floppy disks, 389 KB virtual RAM disk.
Processor(s) -	12 and 6 MHz 80286, 80287 math-coprocessor.
Graphics Display(s) -	NEC GB-1 Multisync ("enhanced" EGA, Hercules) graphics card with NEC 13 inch color monitor. PC's-Limited Universal Graphics Adapter (Hercules monochrome, CGA color) and 12 inch monochrome monitor.
Tape Drive - -	Qualstar™ nine-track drive (1600/3200 BPI) and controller.
Printer/ Plotters - -	Okidata Microline™ 92 graphics printer, HP-compatible Epson 8.5" X 11" pen-plotter.

Approximate Replacement Cost of System - - - - - $7,800.00

Table 3. Time required for conversion from scan-digitized to IMPORT file format.

Transfer from tape to hard disk (12 MHz)	2.25 min.
Transfer from tape to hard disk (6 MHz)	2.42 min.
Conversion to IMPORT format: Step 1 (12 MHz, output to hard disk)	2.25 min.
Step 1 (6 MHz, output to hard disk)	4.67 min.
Step 1 (12 MHz, output to RAM disk)	2.12 min.
Step 1 (12 MHz, output to floppy disk)	2.50 min.
Conversion to IMPORT format: Step 2 (12 MHz, output to hard disk)	5.75 min.
Step 2 (6 MHz, output to hard disk)	10.42 min.
Division into individual themes (12 MHz)	4.08 min.
Division into individual themes (6 MHz)	8.00 min.
Conversion from Lat./Long. to UTM (12 MHz, output to RAM disk)	3.28 min.
Conversion to UTM (12 MHz, to hard disk)	3.50 min.
Conversion to UTM (6 MHz, to hard disk)	6.30 min.
Conversion to UTM (12 MHz, to floppy disk)	5.83 min.
Import into PC-MOSS (MOSS IMPORT) (12 MHz)	1.50 min.
Import into PC-MOSS (MOSS IMPORT) (6 MHz)	2.42 min.
Total Processing Time for Sample Map (12 MHz, output to hard disk)	19.33 min.

The SmartScan data were supplied by Energy Images on a 1600 BPI nine-track tape, and consisted of a single data file with 80 character logical records, and 8000 character physical records. The scan-digitized file was deblocked and transferred directly to the PC hard disk using the Qualstar tape drive and a file-transfer utility. The scan-digitized file required about 1,100,000 bytes of storage. This file was converted into separate IMPORT-format files containing line (306,416 bytes), point (5,732 bytes), and label data (7,936 bytes). Latitude/longitude and UTM coordinate versions of each file were created.

As noted earlier, the scan-digitized files did not specifically include polygon data. However, several features coded as lines did in fact, upon examination of the coordinate streams, form closed polygons. These features were transferred to a separate IMPORT file which, with the exception of tags to designate islands, was identical to a standard IMPORT format polygon file.

Preview of the IMPORT files using the color display and plotting routines showed that the IMPORT-format data, and by inference, the original scan-digitized files, are a good representation of the base-map features. Lines and points are accurate in location and detail, although a small number of secondary streams and offshore features were not captured. It is not known if these items were purposely omitted from the original sample data set, or if the omissions are due to errors in the digitizing or format-conversion process.

The only other problem noted in the plotted maps was extraneous lines in the landnet data. The misplaced lines are due to duplicated coordinates in the scan-digitized file which essentially cause a "pen-down" condition to occur during movement from one section to another. Additional processing steps will be required to remove these errors. Fig. 2 shows examples of the hydrographic and transportation themes plotted from IMPORT format files.

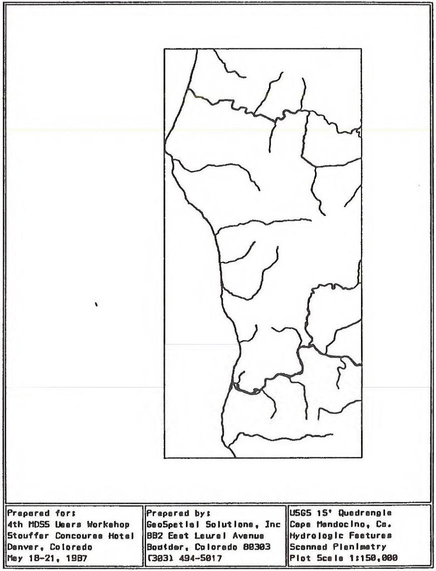
PC-MOSS

Transfer of the reformatted files (point, line, and polygon data) into PC-MOSS was performed using the MOSS IMPORT function. Both Latitude/Longitude and UTM coordinate files were successfully loaded using IMPORT, although the scale factor selected in IMPORT had a significant effect on the Latitude/Longitude data. A scale factor of 0.00001 yielded plottable data. Subjects and items were correctly identified and cataloged by IMPORT, and the newly-created maps successfully added to the project directory. All MOSS commands tested performed correctly for the MOSS maps created from UTM data. Latitude/Longitude data plotted correctly, but AUDIT and AREA produced distances and areas of 0 miles and acres. Fig. 3 includes MOSS maps plotted from the imported files. Fig. 4 shows examples of output from the AUDIT command for the hydrography map (line data) and the Coast Guard station boundary and offshore rocks (polygons).

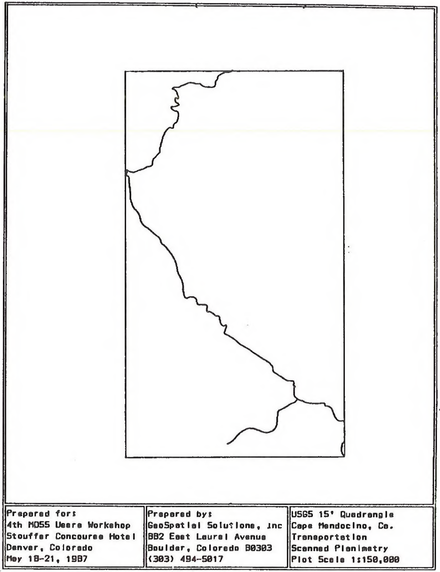
Two types of errors were observed in the imported MOSS files. The most obvious is a duplication of the extra lines in the landnet file as discussed earlier. A second error occurred in the polygon file for offshore rocks. As shown in the AUDIT listing in Fig. 4, "Sharp Rock" has an area many times greater than the other polygons, and is in fact an error. This error occurs due to an extra point in the coordinate stream for Sharp Rock. The extra point is the last coordinate in the stream, immediately following the coordinate that closes the polygon. The problem was rectified by removing the offending point using a text editor.

DISCUSSION

The conversion from the scan-digitized file to IMPORT format files proved to be a relatively rapid and, after initial software development, efficient process. All the original information in the scan-digitized was maintained, and the imported maps were successfully processed within PC-MOSS. With the exception of several apparently extraneous points, the scan-digitized information appears accurate and detailed. Further work is required to determine whether these points were introduced by or



(a)



(b)

Fig. 2. IMPORT-file versions of scan-digitized data, (a) = hydrography, (b) = transportation themes.

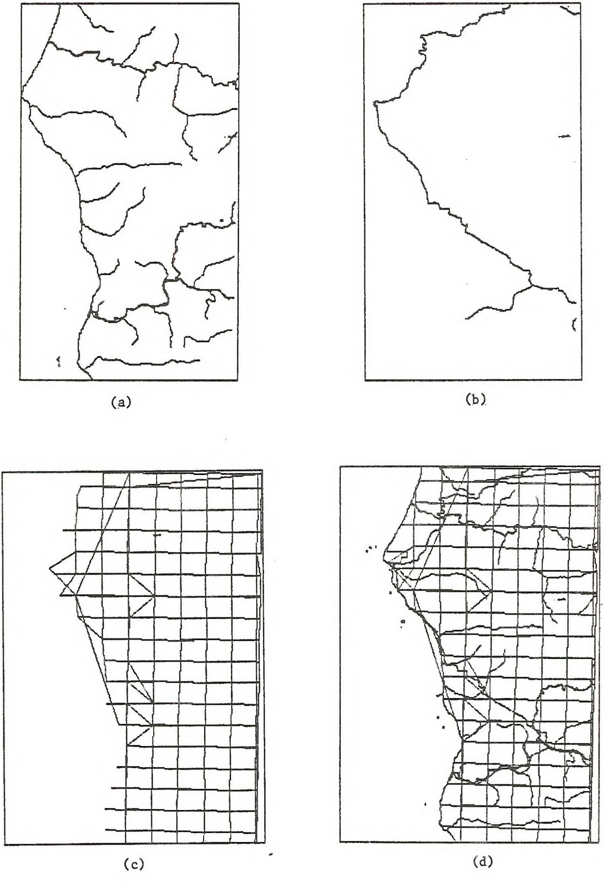


Fig. 3. PC-MOSS plots (screen dumps) of scan-digitized themes, (a) = hydrography, (b) = transportation, (c) = land net, (d) = combined themes.

```
Moss-->? AUDIT CG3

Current Project =TEST

  AUDIT                                       PAGE   1

FOR THE MAP   THERE ARE     1 POLYGONS
                                        PERIM       AREA
            SUBJECT               ITEM (MILES)    (ACRES)   ISLANDS POINTS


7 COAST GARD                        1    3.10      251.11       0       92
                                       ------------------------------------
                                         3.10      251.11       0       92
Execution terminated : 0

Moss-->?
```

```
  AUDIT                                       PAGE   1

FOR THE MAP   THERE ARE    20 POLYGONS
                                        PERIM       AREA
            SUBJECT               ITEM (MILES)    (ACRES)   ISLANDS POINTS


0 SHARP ROCK                        1    0.09      304.90       0       13
0 TWIN ROCKS                        2    0.07        0.25       0       13
0 TWIN ROCKS                        3    0.07        0.20       0       10
0 OFF ROCK                          4    0.09        0.34       0       15
0 BEACH ROCK                        5    0.09        0.33       0       14
0 STEAMBOAT                         6    0.11        0.52       0       16
0 DEVILS                            7    0.37        4.95       0       60
0 DEVILS                            8    0.00        0.00       0        2
0 MUSSEL                            9    0.11        0.49       0       14
0 MUSSEL                           10    0.10        0.37       0       14
0 MUSSEL                           11    0.11        0.44       0       19
0 BROTHERS                         12    0.08        0.24       0       10
0 BROTHERS                         13    0.08        0.27       0       12
0 SEA LION                         14    0.08        0.28       0       16
0 SEA LION                         15    0.09        0.34       0       13
Continue(y/n, cr=yes)
?
```

```
  AUDIT                                       PAGE   1

FOR THE MAP   THERE ARE   127 LINES
                                    LENGTH      CENTER
            SUBJECT            ITEM (MILES)    (MILES)    POINTS


7 CALIF COAS                     1    1.79       0.00       162
7 CALIF COAS                     2    0.41       0.00        37
7 CALIF COAS                     3    1.77       0.00       137
7 CALIF COAS                     4    0.85       0.00        85
7 CALIF COAS                     5    0.83       0.00        74
7 CALIF COAS                     6    0.38       0.00        43
7 CALIF COAS                     7    1.00       0.00        52
7 CALIF COAS                     8    1.39       0.00       123
7 CALIF COAS                     9    1.01       0.00        55
7 CALIF COAS                    10    0.71       0.00        58
7 CALIF COAS                    11    1.01       0.00        88
7 CALIF COAS                    12    0.22       0.00        17
7 CALIF COAS                    13    0.75       0.00        55
7 CALIF COAS                    14    0.87       0.00        59
7 CALIF COAS                    15    1.92       0.00       129
Continue(y/n, cr=yes)
?
```

Fig. 4. Examples of tables (derived from AUDIT) for line and polygon scan-digitized data imported into PC-MOSS.

incorrectly handled in the reformatting software, or whether they are inherent in the scan-digitizing process. It is also necessary to determine why a few features on the base map, which were not visibly different in line type or color from other features, were not captured.

Additional work is required to determine the best method of constructing polygons from the scan-digitized data. The data file tested contained examples of closed polygons, although they were not identified as such. For some uses, no additional processing of the polygons may be required. For other cases, a more sophisticated polygon-handling system is needed. Line segments shared by two or more features appear to be duplicate lines, thus eliminating the likelihood of slivers inherent when the same line segment is digitized more than once for separate features. Based on these characteristics of the scan-digitized data, a semi-automated editing and polygon-closing scheme for the file structure is in development. It should also be noted that Energy Images, Inc. and other scan digitizing firms are considering, and may have already developed, complete polygon-closing routines for their systems.

Processing time to convert from scan-digitized format to IMPORT files and to enter these files into MOSS required about 20 minutes. By refining the software and combining modules into a single routine requiring less reads and writes to disk, the time needed might be reduced by half. The time necessary for the conversion and import steps is felt to be within acceptable limits for operational use.

With the exception of the nine-track tape drive, no special equipment is needed to operate PC-MOSS and the format conversion software on a standard PC-AT class computer. Transfer of the scan-digitized file from tape to the PC could be accomplished via a communications link from another computer equipped with tape drives, but would be a slower process. An office with many PC-MOSS users (and several personal computers) would best be served by equipping one PC with a tape drive unit such as the one described here. This machine could be used to transfer data files from tape to floppy disks for use in other systems, and could serve as a means of entering other data sets such as digital elevation data and satellite imagery. A third alternative is to use the services of an organization which can convert between different types of storage media.

In summary, entry of scan-digitized data into PC-MOSS can be carried out accurately with reasonable effort and cost. A relatively minor amount of additional software development is needed to complete the conversion of scan-digitized data to ready-to-use map files.

A personal computer system equipped with, or with some access to, a tape drive is a useful tool for GIS analysis, and can be used to enter and process data from a variety of sources. Such systems may be particularly valuable for use in field offices, since MOSS data files and maps can be copied to disk and sent through the mail to various sites, where the data can be manipulated and displayed. Ongoing developments leading to inexpensive but powerful microcomputers, integrated raster and vector processing, and less expensive methods of

data capture such as scan-digitizing, will likely lead to new and varied GIS applications in the future.

Acknowledgements. The authors express their appreciation to Energy Images, Inc. (5797 Central Ave., Boulder, CO 80301) for providing the sample data set used in this study. Any problems encountered in the use of these sample data can not be construed as representative of Energy Images, Inc. products.

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Advanced System Applications Session

Section 8

FACILITIES PLANNING APPLICATIONS FOR AUTOGIS

by

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ABSTRACT

The Long Range Facilities Planning Group (ENG-11) at Los Alamos National Laboratory is responsible for current and long range land use planning at the 43-square mile facility and for tracking the current locations of all laboratory structures. These activities require valid base maps and the ability to manipulate geographic information in an efficient and effective manner.

To meet this challenge, ENG-11 has developed land use planning applications for its computer mapping system, AUTOGIS. MOSS is the subsystem most often utilized by ENG-11 for planning purposes.

Currently, the Planning Group uses the system for quick access to and production of map information requested for utilities review and investigation; facilities siting; location and structure inquiries; previewing the visual impact of structures; and comparison with information available through other avenues.

Applications in the development phase include the conversion of the Structure Location Plan, traditionally a paper plat document, to MOSS, primarily because of the need for continual updating of the location of each structure (buildings, permanent and temporary; and utility lines and equipment such as manholes and valves). Also in development is a Development Densities Study which will use a map overlay process of identifying and comparing development constraints and opportunities for quick identification of developable parcels. In addition, a Working Site Development Plan is being developed to translate long range development plans into a working mapping tool suitable for making and evaluating short range facility siting decisions.

The Group employs AUTOGIS as a technically sophisticated planning tool by utilizing its mapping functions for planning purposes. Information currently available to Engineering Division and other Laboratory clients includes the location of several thousand individual items: manmade features such as roads, buildings (permanent and temporary), utilities and communication cables (and appropriate easements), and archaeological sites; and natural features including slope, soils, and surface hydrology. Most of this data has been entered by digitizing aerial photographs; standards are applied for easement locations and buffer zones.

FACILITIES PLANNING APPLICATIONS FOR AUTOGIS

by

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FACILITIES PLANNING APPLICATIONS FOR AUTOGIS

INTRODUCTION

Los Alamos National Laboratory is located on the Pajarito plateau in north-central New Mexico. The plateau, at an altitude of about 7,000 feet, is cut by canyons and cliffs into long, finger-like mesas; and is bounded by the Rio Grande, Santa Fe National Forest, Bandelier National Monument, San Ildefonso Indian Pueblo, and the communities of Los Alamos and White Rock. [Figure 1] The area is rich in wildlife as well as in archaeological and fossil remains.

The Laboratory is divided into work sites called technical areas (TA's), with about 30 sites currently active. Planners have proposed a total of some 46 TA's, with boundaries generally falling along cliff edges or canyon bottoms. The Laboratory provides work space for approximately 12,500 University and contract employees in some 1400 permanent buildings, transportable buildings, and trailers. These include labs, offices, and support facilities such as shops, utilities plants, fire stations, cafeterias, and other facilities appropriate to a scientific community of over 12,000 people.

The location and development of facilities, roads, and infrastructure is constrained by geographic, environmental, and programmatic concerns. Among these constraints are: slope and type of soil; geological fault zones; ground water and hydrology; wind direction and emission zones; impact on habitat, migration and endagered species (both flora and fauna); National Environmental Research Park zones (set aside to provide a control environment for comparison puposes when studying the impact of Laboratory activities in other areas); explosives hazard zones; hazardous waste storage and disposal sites; fossils and archeological sites; security; safety; future expansion; infrastructure and special facility needs; and functional relationships.

The Long-Range Facilities Planning Group is responsible for:

- long-range land use planning, including a Long-Range Site Development Plan and component plan elements;
- mid-range planning elements in a five year time frame;
- current planning, including facility sitings, both permanent and temporary;

- o planning of site improvements such as erosion control, setbacks, and pedestrian traffic patterns;
- o maintenance of Laboratory maps, at a degree of accuracy up to that consistent with two foot contouring intervals; and
- o maintenance of mapping data inventories, including the locations and identities of all Laboratory structures.

As the number of Laboratory employees and the number of structures has grown, this has become an increasingly complex task, and the need for computerized systems to assist in storage, production, and analysis of maps and related data has become increasingly evident.

SYSTEM

To meet this challenge, the Planning Group has developed, over a number of years, land use planning application strategies for the various computer resources available to the group. Lengthy systems research resulted in the selection of the MOSS subsystem of AUTOGIS as the most appropriate GIS vehicle for Laboratory facilities planning. Compatiblility with existing hardware (Data General MV4000), the low cost at which it is available as a public domain program, and the availability of updating and installation from Autometric Inc., are important considerations. More important is its combination of mapping, multiple overlay capability, attribute and textual information, and logical search capabilities. Though developed with plant and animal populations in mind, these are powerful tools for tracking and planning the distribution of buildings and other structures at a facility like Los Alamos National Laboratory.

MOSS information is available onscreen at seven workstations. Each workstation is comprised of either a 4000 series Tektronix graphics console paired with a Data General Dasher for text display, or a 4100 series Tektronix color graphics console. Information requests are often responded to in part with hardcopies of data displayed on the screen. The 4100 series color graphics consoles support color hard copy units, and the 4000 series monochrome consoles support black and white hard copy units. Needs for larger maps or drafting quality maps can be met by plotter output available by means of two Houston Instruments 11"x17" eight pen plotters and a 36"x120' CalComp 1070 series four pen plotter. A Summagraphics digitizer is also available at each of three locations.

For planning related activities not appropriate to a GIS, we use a combination of other computer systems and traditional storage

and presentation methods. The Structure Location Plan (SLP), for instance, combines TA maps with indices of Laboratory structures. For the SLP index, we have chosen to use Lotus 1-2-3, which runs on an IBM PC-AT and more easily accommodates the existing index format than other software we have considered for the purpose. The SLP index can be viewed onscreen at the IBM PC-AT or printed on an IBM Proprinter. The index is combined with maps produced in MOSS and edited to conform to a standard multi-sheet format, and the composite document is published and distributed to groups throughout the Lab.

DATA

Data currently in MOSS include planimetric (several thousand manmade features such as roads, buildings, utilities, and archaeological sites), topographical (contour data and other natural features such as soils and surface hydrology), and planning (long-range plan) maps entered as vector data. These are organized into projects by source and purpose, and into maps by geographic area and topic.

Six current projects, organized by data source and purpose, contain planimetric and topographic data stereo plotted from photographs taken in 1976 and 1986 aerial surveys, data digitized from utilities base maps, long range plan maps, USA states and counties, maps formatted for publication in the SLP, and maps showing environmental hazards. Most of these maps were prepared for our system by outside firms contracted to produce the maps. Other maps are digitized on site as well as generated by cursor or by entering coordinates from the keyboard, or by saving, merging, editing, or otherwise manipulating existing maps.

Within projects, maps are organized by geographic area into sheets or grids designated by a numeric code included in the map name. The topic of the map is indicated by a letter code which forms the other half of the map name. A final letter generally indicates the type of map. Thus 033BLDGS.A is an area (polygon) map of all buildings in grid 033. Roads, buildings, utilities, archeological sites, and other topics can be selected and overlaid as desired, with the window set to any combination of sheets or grids.

Data not now in MOSS include data stored by traditional methods and data stored in some other system. SLP Index data, for example, is stored in Lotus 1-2-3, and consists of structure numbers, descriptions, locations, and comments for thousands of individual Laboratory structures, (permanent and temporary buildings, bridges and retaining walls, wells and cooling towers, bike lockers and dumpsters, manholes and transformers). Each Laboratory structure is assigned a TA designation and number.

These structure numbers appear as subjects in MOSS maps and tie maps and index together.

APPLICATION

AUTOGIS has proven to be a versatile and powerful tool appropriate for a wide range of applications, from facilities siting and information requests, to site maps, to facilities planning.

When a request is made for the siting of a facility, roads and buildings in the immediate location are plotted on the screen and hardcopied. The proposed building is added to the map, and the map is distributed to those offices and individuals concerned with the approval of that siting. [Figure 2] In conjunction with a siting request, a hardcopy of utilities, archeological sites, nearby hazards, or a profile showing the visibility of a structure from neighboring land may also be produced and distributed to appropriate parties. In this manner, the review of a proposed siting can be accomplished quickly and with careful consideration of any mapped constraints. The use of MOSS also allows us to respond quickly to requests for other mapping information, such as the coordinate location of a building or other structure, the location and elevation of a drainage swale, or the presence of underground utility lines in a construction site.

The SLP, formerly a paper plat document, is being converted to a computerized document. [Figure 3] Storing these maps in AUTOGIS permits the window and scale of any map plot to be changed easily. At the same time, the accuracy of the maps is enhanced by the use of arial survey planimetric data as a base source of information. This saves weeks of time often required to redraw an entire SLP site by hand when changing the scale, making corrections, or updating a map. The index pages for this document, previously hand Leroyed in ink on mylar, have been entered into LOTUS, where they can be easily edited, sorted, and formatted for publication.

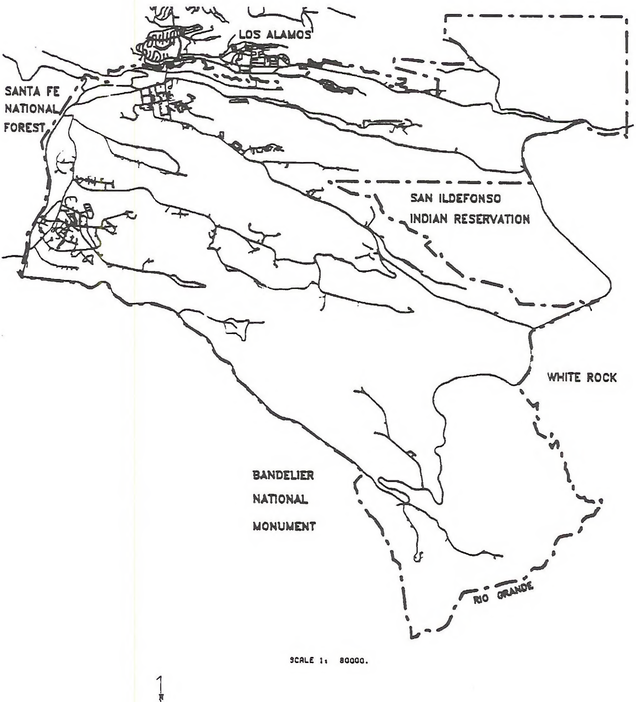
The Group employs AUTOGIS as a technically sophisticated planning tool by utilizing its mapping functions for planning purposes. The visual impact of individual structures can be checked by developing profiles or 3D images [Figure 4], and cell data can provide overlays of slope or other statistical map information. [Figure 5] Long-range plan maps, overlaid on existing structures and topography, assist in planning the siting of new structures in locations compatible with planning goals. [Figure 6]. A variety of siting constraints can be quickly mapped and considered, with standards applied to the graphic representation of easement locations and buffer zones.

The Development Densities Study will use MOSS maps of easements, buffer and security zones; existing boundaries of development; slopes; opportunities and constraints to future development; etc. to allow planners to examine each area for developable sites; to estimate the number of people each site can accommodate based on available land and existing infrastructure; and to estimate the cost of providing access and utilities to each site based on the distance to utility mains, access roads, and topography. The Laboratory can choose to predevelop and thereby encourage development in preferred locations. Likewise, certain sites might be restricted for development because of an abundance of archaeological sites or because development costs are unacceptable.

In addition, a Working Site Development Plan will be used as a tool for making and evaluating short range planning and development decisions. Computerized mapping will incorporate the abilities to overlay specific long-range plans and to manipulate various development scenarios. We will thus be able to more clearly understand the ramifications of individual siting decisions on traffic, circulation and parking; land coverage; and functional adjacencies, while increasing our ability to present these concepts graphically.

Future applications may include the use of MOSS to track populations and traffic patterns and assist in planning road configurations and space allocations. Laboratory planners continue to investigate potential uses of this powerful computerized planning tool in an effort to streamline its planning operation and maximize the potential of a small staff given an increasing demand for development and a decreasing amount of developable land.

LAUR 87-1606



AUTOGIS

FIGURE 1

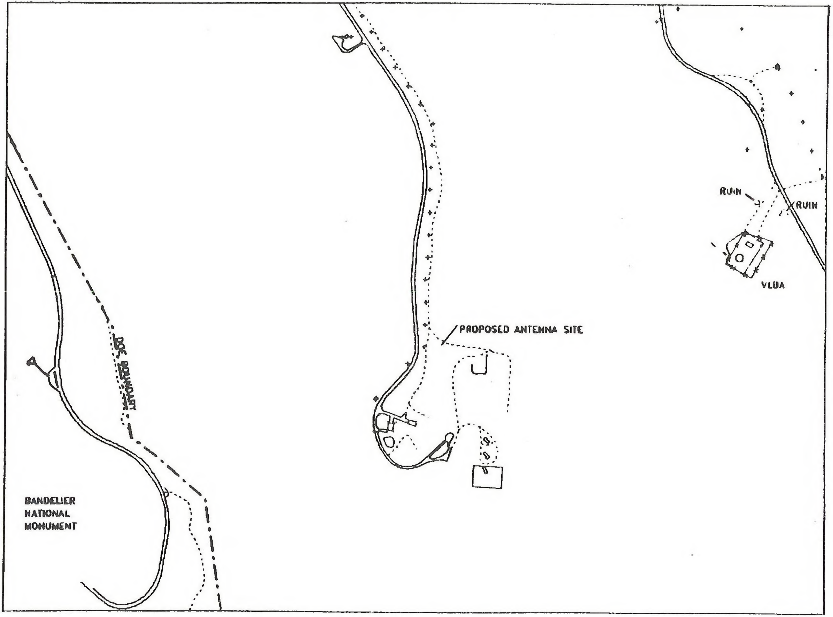

RUIN
RUIN
VLBA
PROPOSED ANTENNA SITE
DOE BOUNDARY
BANDELIER
NATIONAL
MONUMENT

FIGURE 2

STRUCTURE LOCATION PLAN MAP

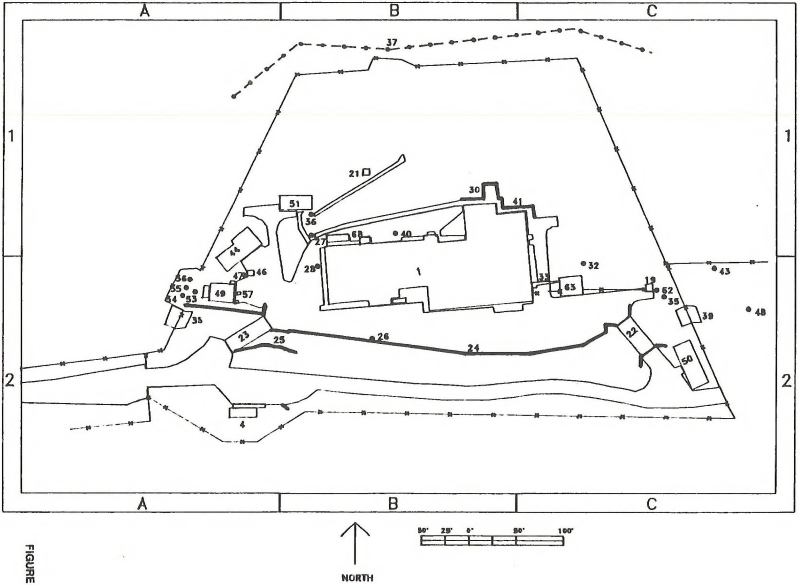


FIGURE 3

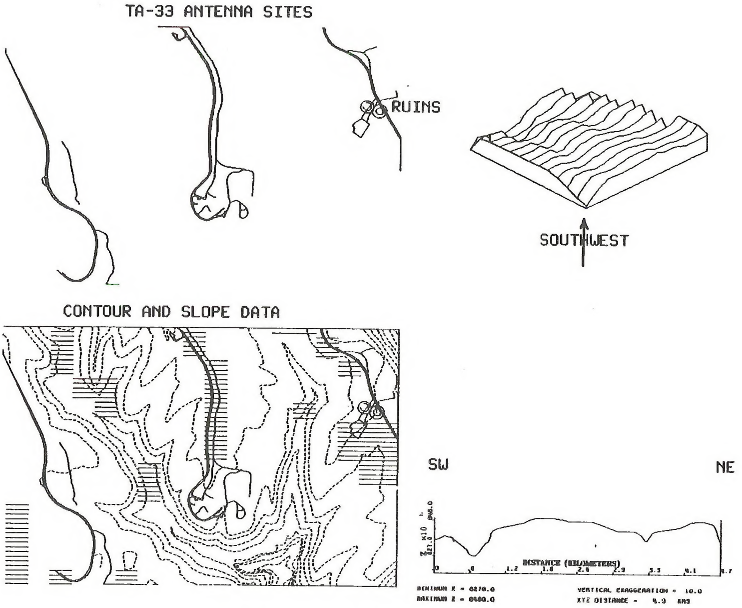
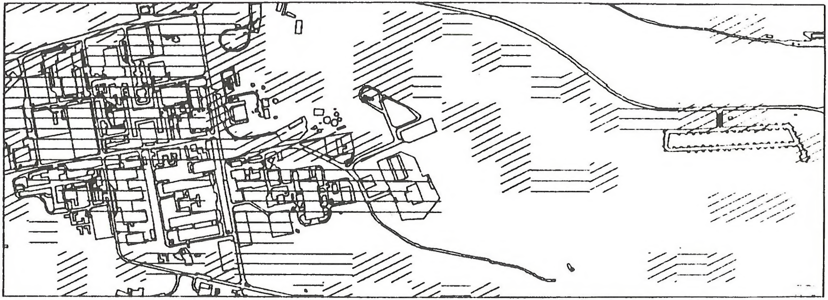

TA-33 ANTENNA SITES
RUINS
SOUTHWEST
CONTOUR AND SLOPE DATA
SW
NE
VERTICAL EXAGGERATION = 10.0

FIGURE 4



SHADE USED WITH SLOPE TO IDENTIFY DEVELOPABLE LAND. REPRESENTS A SLOPE OF 5% OR LESS; REPRESENTS A SLOPE OF 5%-10%.

FIGURE 5

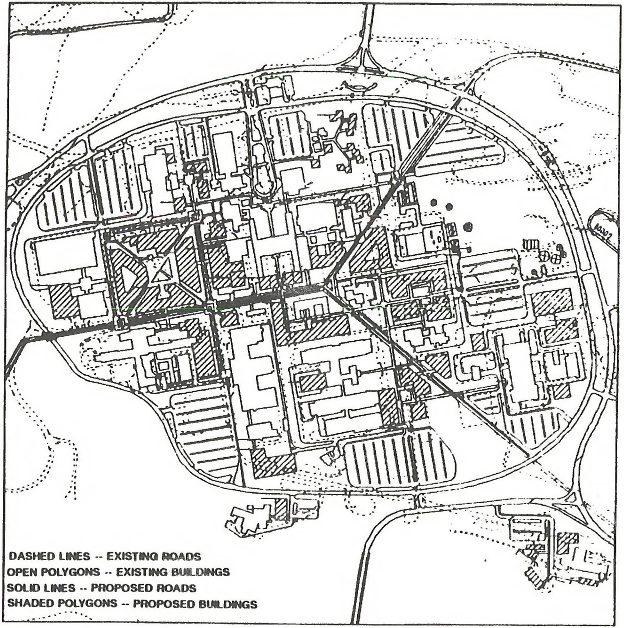

DASHED LINES -- EXISTING ROADS
OPEN POLYGONS -- EXISTING BUILDINGS
SOLID LINES -- PROPOSED ROADS
SHADED POLYGONS -- PROPOSED BUILDINGS

FIGURE 6

APPLICATIONS OF THE MAPS SYSTEM TO SUBGLACIER HYDROLOGY

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ABSTRACT

Geographic Information System (GIS) software offers many analytical possibilities to existing data sets that have yet to be explored. Using the MAPS system, mapped aerial distributions of physical parameters can be numerically modified by trigonometric functions, powers, or log functions, averaged over specified areas, or combined with other mapped parameters through various numerical operations to produce maps of the derivative physical parameter. Additionally, quantities can be summed over areas or summed by categories.

Examples are given where maps of glacier surface topography and ice thickness are combined through mathematical formulas to yield a map of the flow direction of basal water and again combined to yield a map of basal shear stress. These parameters have not been expressed in map form in the past, but only as numbers at specific locations or as a series of values along a profile. The resultant maps allow the glaciologist a better

understanding of the aerial distribution of the basal water flow and basal shear stress, and give the engineer a rapid means of delineating under-ice drainage boundaries for hydropower assessment.

INTRODUCTION

Understanding flow instabilities and the transition from "slow" flow (typically 0.1 to 1.0 meters per day) to "fast" flow (typically 1 to 100 meters per day) in glaciers has been one of the major unsolved problems in glaciology for the last five to ten years. Work on this problem has focused mainly on the role of water at the glacier bed in reducing the effective coefficient of friction and causing basal sliding. Most "normal" glaciers are believed to flow largely by internal deformation of the ice. Some additional flow can occur in summer due to basal sliding caused by increases in the basal water pressure that result from precipitation or strong glacier surface melt. These events supply water to the glacier plumbing system at a rate which temporarily exceeds its capacity, causing an increase in basal water pressure and hence glacier sliding. Although there is considerable debate about the nature of water flow at the glacier bed, there is strong evidence that for most normal valley glaciers it is largely in a converging network of channels with most of the flow in one or two primary channels near the center of the glacier. There are two physical principles controlling this. The direction of water flow at the bed of a glacier is determined by the potential gradient, which is a function of the glacier surface slope and glacier bed slope and is typically convergent. Also, larger conduits tend to grow at the expense of smaller ones, due to greater heat dissipation in the larger ones

relative to their wall area, which causes faster melting, and to water drainage from smaller, higher pressure conduits to larger, lower pressure ones. (Paterson, 1981)

Contrary to this norm, visual observations of Capps Glacier led us to believe that the basal water flow might be divergent for as much as the lower 8-12 km of this 40 km long glacier. Most of the subglacial water emerges not at the terminus, but in two channels along the glacier margins well upglacier from the terminus (2 km up the south side and 6 km up the north side). Some water also emerges at the terminus in numerous small channels scattered along the glacier front. These observations are all consistent with a divergent basal water system.

If the glacier plumbing system were in fact to change at some point in space from a convergent network with most of the water in one or two channels to a divergent system with the water more equally carried by many small channels, one might expect some significant difference in its dynamic response to changes in water input as compared to most "normal" glaciers.

Ice radar measurements of ice thickness were taken on lower Capps Glacier in 1981 as part of a volcano hazards study that included measuring the snow and ice volume on Mount Spurr, the source of Capps Glacier. As part of that study the glacier thickness was contoured. This and the surface topography provided us with the basic information needed to construct a three dimensional potential surface that would control the direction of basal water flow as well as a map of basal shear stress.

BASAL WATER FLOW DIRECTION

The direction of water flow at the bed of a glacier is determined by the glacier surface slope with some influence from the glacier bed slope. Assuming that both the surface slope and the bed slope are less than about 20 degrees and that the difference between them is less than about 10 degrees, the potential ϕ at any point is approximated by:

$$\phi \approx \phi_0 + \delta_i g(h_s + 0.1y)$$

where ϕ_0 is an arbitrary constant, δ_i is the density of ice, g is acceleration due to gravity, h_s is the elevation at the surface, and y is the elevation at the glacier bed (Paterson, 1981). The gradient of this potential surface is the pressure gradient that drives water flow at the glacier bed. The aspect of this potential surface at any point is the direction in which the pressure gradient is maximized and therefore the direction of water flow.

Surface topography was digitized using AMS from a composite topographic map at 1:50,000 made from existing U.S. Geological Survey Tyonek B-7 Quadrangle, 1958 and Tyonek B-6 Quadrangle, 1958. Thickness contours were digitized from a map of ice thickness made from ice radar measurements (March, Mayo, and Trabant, in preparation). The boundary of Capps Glacier was digitized from field maps. The boundary map was used as a mask in gridding the surface and thickness maps to be used for later calculations. The boundary was rasterized using POLYCELL. CONSTANT then

gave the resulting map a value of 1. Finally, the mask was formed by CROSSing the boundary map with the constant map. The digitized surface contours and thickness contours were rasterized using quadrant GRID and a matrix of 11, and using the mask to produce a map of the glacier area only.

Several attempts were made at gridding the maps before the right combination of parameters was found. A 100m x 100m grid was tried first, but proved to be too fine a grid in terms of processing time. 250m x 250m was found to be a good compromise in terms of processing time and information given. Because the digitized points were closer together along contours than between them, the weight function was inappropriate, and the quadrant function was used. Several matrix sizes were tried, and 11 proved to make the smoothest map.

The surface map was SCANned using AVERAGE and MATRIX 3 to smooth the data further. Edge effects were bothersome, so the glacier boundary was again POLYCELLed and combined with the surface contours to alleviate the problem. The result was then converted to meters using MATH to match the thickness map. The thickness map was subtracted from the surface map to produce a map of the glacier bed. A potential map was then produced by adding the surface map to 0.1 times the bed map. Because the potential map is not readily understandable to the layman, a map of the direction of water flow was made by finding the aspect of the potential surface. The aspect expresses the direction in which something is facing; here, the direction of water flow. Alternatively, the potential can be contoured,

and the direction of water flow is known to be perpendicular to the contours.

The resultant map of water flow direction at the base of the glacier confirms the hypothesis of a divergent water flow under the lower part of Capps Glacier. Under the upper part of the glacier, disregarding ever-present edge effects, the map shows water flow travelling down the center of the glacier bed. Under the lower glacier, however, the water flow direction is shown to diverge as predicted.

BASAL SHEAR STRESS

In the simple laminar flow model that is commonly used to study glacier flow, the driving force for glacier motion is that component of the glacier's weight parallel to the plane of the glacier bed (here assumed also approximately parallel to the plane of the glacier surface). If there is no sliding of the glacier on its bed, then this component of the weight is balanced by and therefore equal to the shear stress τ_b across the base of the glacier. The shear stress is determined by

$$\tau_b = \delta g h \sin \alpha$$

where τ_b is basal shear stress, δ is density of ice, g is gravity, h is ice thickness, and α is surface slope (Paterson, 1981).

To produce a map of basal shear stress, a map of surface slope was calculated from the map of surface elevations made previously, using

SLOPE with average and matrix 3. This map was then converted to a map of slope in radians using MATH. The map of ice thickness was multiplied by the sin of the surface slope map and several constants to obtain a map of basal shear stress.

CONCLUSIONS

It is very important philosophically to examine a sequence of spatial operations with spot checks or even profile checks to confirm that the output is what is expected. In most cases it is a simple matter to examine a single cell value and run a rough check by hand calculator. In other cases examining a series of cell values along a line or profile is necessary to determine whether a function is performing an operation in the expected manner. For example, when we originally gridded our digitized contours, the gridded values did not flow smoothly between contours, but seemed to be stepped. Stepping was not apparent in the original data, so we applied an AVERAGE function to smooth out the steps and generate a grid of values which we felt more accurately represented the original data.

We have found raster-based GIS software to be very useful in producing map views of parameters that glaciologists have formerly seen only as isolated numbers. Mapped distributions of physical parameters can be transformed using trigonometric functions, powers, or log functions, and they can be combined using various numerical operations. Results can be displayed in cell (raster) format or can be contoured. The methods can be applied to any aerially distributed parameters. Specifically, the technique

was used to confirm the hypothesis that basal water flow under Capps Glacier becomes divergent in the lower reaches of the glacier, as well as to examine the basal shear stress of the glacier. A diagram of the method followed is shown in Figure 1.

REFERENCES

Paterson, W.S.B. 1981. The physics of glaciers. Second edition. Oxford, etc., Pergamon Press, Ltd., 380 p.

PROJECT FLOW DIAGRAM

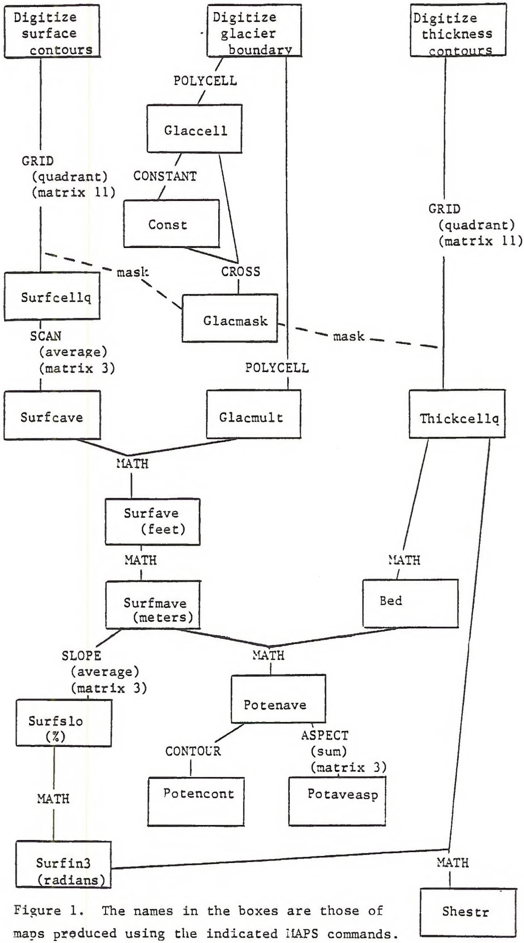

Figure 1. The names in the boxes are those of maps produced using the indicated MAPS commands.

EVALUATION OF SPRUCE FIR MORTALITY IN THE SOUTHEAST UTILIZING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGIES

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USDA FOREST SERVICE, Forest Pest Management, Region 8

INTRODUCTION

Concern about mortality in the spruce-fir forest of the southeastern United States indicated an immediate need to conduct a survey to map the extent and severity of the damage. The forest type is comprised of red spruce (Picea rubens Sarg.) which occurs from North Carolina to Nova Scocia and Fraser fir (Abies fraseri [Pursh]Poir.) which occurs only in North Carolina, Tennessee and Virginia.

Because of the geography and topography of the region, spruce-fir forests in the south occur as a series of island-like stands at high elevations. The Southern Appalachian spruce-fir is believed to be threatened by an exotic insect pest, the balsam woolly aphid (Adelges piceae Ratz.), by atmospheric deposition of pollutants, and possibly by other agents. This forest type represents an extremely valuable resource in the south because of its unique natural beauty and its importance for recreation. It is also considered by many to be a threatened species type because of its marked decline in area.

In addition to the threat of the balsam woolly aphid and its impacts, which are greatest upon Fraser fir, the spruce-fir type may be particularly vulnerable to atmospheric deposition of pollutants. These high elevation forest types probably receive more deposition because of the higher precipitation and cloud immersion than lower elevations. Introduction of the balsam wooly aphid into the southern Appalachians provided a wealth of information concerning mortality of spruce and fir. However, recent attention has shifted to the role of atmospheric deposition in the higher elevations. Red spruce may be more directly threatened by air pollutants as indicated through declining annual radial increment. The complicated nature of the spruce-fir forest mortality and the difficulty in establishing a cause and effect relationship indicated a more pressing need for establishing baseline data on the current status of the spruce-fir type and its relationship to previously recorded geographic information which may be analyzed through the utilization of a geographic information system (GIS).

For this project, aerial photography was acquired and interpreted by USDA Forest Service, Forest Pest Management, and entered into a GIS. These data were analyzed in relation to other geographic and land use information to assess the mortality and determine the extent of the spruce-fir type in the southeast. There is a general transition from the use of manual maps to digitally encoded (automated) maps. Also, the digitally encoded geographic maps are used to create a data model of geographic information in which the geographic relationships and various attribute features of geographic data are

represented in a database environment. This project will produce graphics, and more specifically, maps which may also be models of the analysis of various interactions of forces at work which may mold the mortality of spruce-fir in the southern Appalachians.

There is an increasing awareness and interest in the phenomena occurring within the spruce-fir forests. This interest is increasing the demand to develop better ways to record, store, analyze, merge, retrieve and display geographic information to analyze these phenomena. A GIS will provide the most efficient, and probably the only, means to analyze data bases expanding time and physiographic regions.

OBJECTIVES

1. Locate and delineate on maps all red spruce and fraser fir in the southern Appalachians.

2. Classify all red spruce and fraser fir mortality (percent of dead standing trees) visible on aerial photographic coverage in the states of Tennessee, North Carolina, and Virginia.

3. Using a combination of aerial photographic sampling and ground checks, estimate losses within the spruce-fir type.

4. Acquire large scale aerial photography of previously established research plots.

5. Develop and implement a geographic database on the extent and intensity of mortality in the spruce-fir type in North Carolina, Tennessee and Virginia.

6. Provide for comparisons between the extent and intensity of mortality in relation to other geographic information through the computer analysis, storage and display of spacial (geographic) information.

METHODS

Aerial Photographic Acquisition

Color infra-red aerial photography at a scale of 1:12,000 of the entire spruce fir type was acquired in stereo during the summer (leaf-on season) of 1984. An Aero Commander 680-F equipped with an RC-10 camera and a geographic coordinate referenced navigation system was used to acquire the photography. In the winter of 1985, true color positive transparencies were acquired in stereo during the leaf-off season over the entire spruce-fir range at a scale of 1:12,000. This photography was used to modify the previously identified boundaries and mortality strata for more specific and detailed evaluations. Underflights were made of previously established research plots at a scale of 1:4,000. All photography was indexed on USGS 1:24,000 scale topo sheets, and the photography and maps were available to other investigators.

PHOTO INTERPRETATION

Boundaries of the spruce-fir were delineated by skilled aerial photographic interpreters directly on the aerial photographic transparencies using Bausch and Lomb 240 Zoom stereoscopes mounted on MIM 4 Richards light tables. For this project, the spruce-fir type was defined as 50 percent or more of the dominant and codominant trees within the stand component being spruce and/or fir. The boundaries of the type and mortality classes were then transferred to 1:24,00 scale USGS topo maps. Within the spruce-fir type, the following categories of mortality were recognized: (1) Light to moderate - less than 30% of the standing dominant and codominant trees dead; (2) heavy - 30% to 70% standing dominant and codominant trees dead; and (3) severe - greater than 70% of the standing dominant and codominant trees dead.

Stratification and Selection of Sample Plots

During the photo interpretation, individual areas were sampled within the three mortality classes. Each mortality class was randomly sampled in proportion to the area of spruce-fir type affected. A total of 232 study sites, 1/5 acre in size were selected on Mt. Mitchell, Roan Mountain, Blue Ridge Parkway and Great Smoky Mountain National Park. Randomly selected 1/5 acre plots were viewed in stereo to determine the number of dead spruce and fir trees and the total number of spruce and fir trees visible in the plots.

Ground Survey

A total of 132 of the 1/5 acre photo plots were randomly selected as plots for the ground phase of the evaluation. Ground crews located the center of the photo plots on the ground and marked them with a metal stake. General information such as slope, aspect, and the presence of balsam woolly aphid were collected. Starting at the center of the plot, a cluster of five sampling plots were established with the center stake serving as the first point and the other four systematically arranged in a procedure similar to that used by the Southeast Forest Experiment Station, Forest Inventory and Analysis work unit and described in their field instruction book. Data were taken at each point in a variable size plot established by a prism with a basal area factor of 37.5. A fixed radius plot of 6.8 ft. was also established at each point in the cluster. There were two sets of data taken at each point in the cluster on two separate data sheets. The following data was taken on each tree for the variable size sampling points: (1) species; (2) DBH; (3) condition; (4) total height; (5) crown position; and (6) destructive agents. On the 6.8 ft. radius plots the following data was taken on each tree one inch DBH or greater: (1) species; (2) DBH; (3) condition; (4) destructive agents; and (5) crown position.

Map Digitizing and Data Entry

Maps were reviewed before data entry to verify proper attribute placement and polygon closure, as well as edge mapping adjacent quad sheets. The boundaries of the spruce-fir type, with the interior areas classified by mortality, were

digitized from 27 quad sheets. The MOSS family of software was used as the GIS for data entry, analysis and display of the data. The GIS is a set of software for encoding, transformatting, analyzing, and displaying map and other geographic based information. The system includes 3 components: (1) The Analytical Mapping System (AMS) for digital data entry; (2) Map Overlay and Statistical System (MOSS) and Map Analysis and Processing Systems (MAPS) for data processing, analysis and display; and (3) Cartographic Output System (COS) for plotting and producing maps. This software was installed on a MV 4000 Data General minicomputer with over 800 megabytes on line disk storage capacity along with a high density tape drive. The system also includes two large format digitizing stations with graphic terminals, color graphic display stations, image display station, and text terminals. An eight-pen plotter provides map output products.

Primary data themes i.e., those data layers which would be found for all topo maps containing spruce-fir type, were created as follows: (1) spruce-fir type boundaries; (2) spruce-fir mortality classification; (3) topography; (4) transportation; (5) ownership; and (6) drainage. Secondary data themes which included information over portions of the spruce-fir type were: (1) Study plot locations;(2) photo index; (3) disturbance history; (4) balsam woolly aphid protection boundaries; (5) balsam woolly aphid mortality history; (6) balds; (7) spruce-fir forest type (with hardwood component) for the Great Smoky Mountain National Park; (8) railroad-right-of ways for previous logging activities; (9) 1960 mortality map for Mt. Mitchell; and (10) other data themes as they become available.

AMS digitizing allows the user to enter information found on the base maps and data overlays from base maps into the system. It is entered by means of a digitizing tablet and a cursor which sends the information to the computer where it is mathematically translated into a coordinate pair based on the map center. When the digitizing is completed, the map is put through a rigorous visual and analytical verification of the data. Completion of the verification process allows the data to be moved into the database. Upon completion of digitizing all data are reformatted for analysis by MOSS.

A wide variety of analytical functions are available in MOSS to analyze geographic information for a variety of purposes. Examples (by no means an inclusive list) of several different procedures which may be followed are: (1) graphic overlays in which several maps are overlaid one on another to determine which map elements coexist at particular locations; (2) topological overlays in which geographic elements from two or more separate files are joined or related to one another to create an intergrated cartographic file; (3) polygonization in which linked segments are chained together to form a polygonal boundary; and (4) relational matching in which two attributes are related to one another to form the desired functional purpose.

In using maps in the traditional way, the method has been to look at the maps in order to interpret them. Geographic relationships and meanings have generally been derived through the process of human analysis. Through the use of a GIS there has been a significant reduction in the need for this human analysis. As a result, a wide variety of the interpretations of the data, with a minimum of human intervention, can be achieved through the use of fully automated procedures. In addition, there are many advantages to using automated GIS technologies, such as maintaining data in a physically compact

format, retrieved at much greater speed, and at a lower cost. There is also the tendency to integrate data collections, spatial analysis, and a decision making process all into one common information base. All of the automated techniques involve a substantial amount of processing and/or editing subsequent to the initial data capture. These may include: (1) plotting or printing of digitized coded data for visual editing; (2) topological checking to insure correctness within data sets; (3) removal of concurrent lines captured to represent the same map vector; (4) polygonization of arc information into polygons; (5) editing XY coordinate data; and (7) edge map analysis.

Map Production

The COS subsystem of the MOSS family of software was used to produce maps displaying the primary data themes for all the spruce-fir areas in the southeast.

RESULTS AND DISCUSSION

Data were analyzed by region of spruce-fir type in the southeast as follows: (1) Great Smoky Mountain National Park; (2) Blue Ridge Parkway;(3) Roan Mountain; (4) Grandfather Mountain; (5) Mt. Rogers/White Top Mountain; and (6) Mt. Mitchell. Data were also compiled to summarize conditions throughout the southeast. At this time, distribution of the spruce-fir and mortality in relation to elevation has been the primary focus of investigations. Preliminary results are available on the relationship of the spruce-fir type and other geographic features.

Maps displaying the distribution and the stratification of mortality in relation to all primary data themes were produced with legends indicating the total number of acres of spruce-fir type classified by mortality. An analysis of the data for spruce-fir mortality by region will include the following GIS analysis: (1) mortality classification expressed in number of acres and percent of area by geographic region (Table 1); and (2) acres of mortality stratified by elevation expressed as a percent of total area by region (Table 2). Spruce-fir mortality data analysis,based solely on ground truth will include: (1) percent of spruce and fir mortality classified by elevation for each region (Table 3); and (2) percent of the stand component for spruce and fir classified by elevation for each region (Table 4).

TABLE 1. SPRUCE-FIR FOREST IN THE SOUTHEAST CLASSIFIED BY MORTALITY

Geographic Area	Light Acres	%	Heavy Acres	%	Severe Acres	%	Total Acres	%
			MORTALITY CLASSIFICATION					
Great Smokey Mountain National Park	35,759	73	2692	6	10,365	21	48,816	74
Mt. Mitchell	5,409	75	289	4	1,514	21	7,212	11
Roan Mountain	256	17	583	38	698	45	1,537	2
Mt. Rogers/ White Top Mtn.	1,582	100	0		0		1,582	2
Grandfather Mtn.	659	71	124	13	145	16	928	1
Blue Ridge Parkway	2,058	37	550	10	2,989	53	5,597	10
TOTAL	45,723	70	4,238	6	15,711	24	65,672	100%

Light = 30 % standing dead dominant and codominant trees
Heavy = 30% - 70% standing dead dominant and codominant trees
Severe = 70% standing dead dominant & codominant trees

TABLE 2. SPRUCE-FIR MORTALITY IN THE SOUTHEAST STRATIFIED BY ELEVATION

	Mortality (% of Area)													
	4600 ft.			4600-5200 ft.			5200-5800 ft.			5800-6400 ft.			6400 ft	
Geographic Region	L	H	S	L	H	S	L	H	S	L	H	S	L	H
Great Smoky Mtn National Park	7	0	0	39	2	0	26	3	15	1	1	5	0	0
Mt. Mitchell	4	0	0	22	0	0	29	1	2	19	3	16	1	0
Blue Ridge Parkway	1	0	0	6	1	1	26	8	34	5	1	18		NA
Roan Mountain	0	0	0	1	1	0	10	16	24	5	22	21		NA
Grandfather Mountain	7	0	0	28	1	1	35	12	12	1	0	1		NA
Mt. Rogers/ White Top	2	0	0	54	0	0	44	0	0		NA			NA
Spruce-Fir Type in the SE	7	0	0	34	1	1	25	3	13	4	2	9	0	0

L = 30% mortality
H = 30-70% mortality
S = 70% mortality

TABLE 3. RESULTS OF GROUND TRUTH FOR SPRUCE-FIR MORTALITY BY ELEVATION STRATUM

Area	4200-5400 ft.				5400-6000 ft.				6000-6500 ft.				Overall			
	Spruce		Fir		Spruce		Fir		Spruce		Fir		Spruce		Fir	
	N	%[1]	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Mt. Mitchell	102	10	4	100	83	13	57	23	18	39	54	72	203	14	115	49
Roan Mountain	17	6	27	67	83	1	181	50	16	13	129	30	116	3	337	44
Blue Ridge Parkway	12	0*	14	0*	128	5	160	93	5	0*	3	0*	145	5	177	84
Great Smokey Mountain National Park	105	13	44	100	147	6	120	88	25	4	14	86	277	9	178	91

N = No. of trees sampled.
*Insufficient sample size.
1 / % of Sampled trees dead

TABLE 4. SPRUCE-FIR FOREST TYPE STAND COMPONENT (PERCENT) BY ELEVATION STRATUM FOR GROUND TRUTH SAMPLES

Area	4200-5400 ft.			5400-6000 ft.			6000-6500 ft.			Overall		
	S	F	Other	S	F	Other	S	F	Other	S	F	Other
Mt. Mitchell	58	2	40	35	24	41	22	66	12	41	23	36
Roan Mountain	19	31	50	27	59	14	11	87	2	21	62	17
Blue Ridge Parkway	21	24	55[1]	33	42	25	63	38	0[1]	32	39	29
Great Smoky Mountain National Parkway	52	22	26	43	36	21	64	36	0	48	3	21

1/. Insufficient Sample Size
S = Red Spruce
F = Fraser Fir

At this point, severe mortality appears to occupy a greater proportion of the area at higher elevations as opposed to lower elevations. These higher elevation stands also contain a much greater percentage of fraser fir. Fraser fir mortality, as observed in this study, is very consistent with reports of published balsam woolly aphid activity. A very strong correlation between ground sample points and aerial sample points was found.

It should be noted that this survey is a one-point-in-time analysis of mortality within the spruce-fir type and certainly not a measure of mortality over a period of time. It is known that a spruce or fir tree may stand for up to 20 years and still may be visible on aerial photographs. Further investigations will be necessary to develop a stronger cause and effect relationship to account for mortality observed during this survey.

In general, the spruce-fir type in the southeast occupies 65,672 acres. Seventy-four percent of this forest type was found to occur on the Great Smoky Mountain National Park,followed by Mt. Mitchell, 11%; Blueridge Parkway, 10%; Roan Mountain, 2%; Mount Rogers/White Top, 2%; and Grandfather Mountain, 1%.

Within the spruce-fir type, 70% of the total area was classified as light to moderate mortality (less than 30% standing dead trees); heavy - mortality occupying 6% of the total area (30% to 70% dead), and 24% of the total area classified as severe mortality (greater than 70% dead).

The mortality classifications in the southeast are considerably different than those found in other areas of the northeast. This difference in classification is due primarily to the extentuating circumstances of balsam woolly aphid known to attack and kill great numbers of Fraser fir in the southeast.

USE OF A GEOGRAPHIC INFORMATION SYSTEM AS A TOOL
FOR MAKING LAND USE MANAGEMENT DECISIONS FOR
COASTAL WETLANDS IN A STATE REGULATORY PROGRAM

Terry W. Howey and James H. Blackmon*

ABSTRACT

The largest concentration of coastal wetlands in the contiguous United States, nearly 40% of the total wetlands, occurs in Louisiana. Within the framework of state govermnent, one state agency responsible for protecting and managing activities which occur in these wetlands is the Coastal Management Division of the Louisiana Department of Natural Resources. As a tool for making decisions concerning proposed activities and the evaluation of possible consequences of, or alternatives to, these activities, a geographic information system (GIS) has been implemented.

The GIS is based on a Data General MV-10000 computer and uses the public domain Map Overlay and Statistical System (MOSS) as the main software package which provides information to coastal resource analysts to aid in the review of proposed activities. Upon receipt of an application to conduct a regulated activity in the coastal zone, the GIS is used to provide a standard package of information based on the location of the project. The data provided includes types and acreages of habitat in the vicinity, changes in habitat which have occurred over a 22 year period, proximity of sensitive areas, unique habitats, bird rookeries, waterfowl concentrations, and other relevant data available in the data base. Additional information or analyses may then be made available at the request of the technical staff to address specific questions or evaluate possible alternative routes, sites or methods which would result in the minimum alteration or adverse impacts on Louisiana's coastal wetlands.

Monitoring wetlands areas and updating the extensive map data base held by the Coastal Management Division is conducted using the ERDAS software and LANDSAT thematic mapper data along with aircraft borne high altitude thematic mapper simulator data obtained from flights over the coastal areas. These provide the capability to use the GIS to monitor wetlands for the occurrence of unauthorized activities. The MOSS/ERDAS interfacing capabilities of the GIS can also be used to update the division's map collection and provide current data for use by the technical staff in making decisions which may effect Louisiana's valuable coastal wetlands.

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INTRODUCTION

The coastal wetlands of south Louisiana comprise approximately 40% of all wetlands in the contiguous United States, and consists of about 3.2 million hectares of swamp, fresh, brackish and saline marshes (Turner and Gosselink, 1975). These wetlands are extremely important to Louisiana for many reasons: They support very large commercial and recreational fisheries; they serve as a nursery area for many species of fish and shellfish; they provide important waterfowl habitat; they support a major trapping industry for nutria, muskrat, mink and alligator; they help support an increasingly important tourist industry; they provide an important natural barrier and buffer for the forces of tropical storms and hurricanes.

Louisiana's coastal wetlands are now disappearing at an alarming rate. It is estimated that land loss in coastal Louisiana is from 102 Km^2/yr. (Gagliano et al. 1981) to as much as 130 Km^2/yr. (Salinas et al. 1986) and this rate appears to be increasing geometrically. This loss of wetlands can be attributed to a variety of causes which probably all contribute to some loss, and may have interacted to cause the accelerated loss observed in recent years. These factors include the loss of sediment input resulting from leveeing of the Mississippi River, land subsidence, sea level rise, and direct actions by man such as gravity and forced drainage projects, fill projects and canal dredging.

Recognizing the importance and sensitivity of the state's coastal wetlands and the pressures on them, Louisiana enacted legislation in 1978 for management of the resources of the coastal zone. In 1980 the state program began regulating activities in the state through the Coastal Use Permit process under funding from the NOAA Office of Coastal Zone Management. Each year since the permitting process began, from 1,000 to 2,000 applications to conduct activities in the Louisiana coastal zone have been received. From program approval in October 1980 through December 1986 CMD has processed a total of 10,414 permit applications, conducted 2,920 program consistency determinations and investigated 583 reported unauthorized activities (began 1983).

With such a large number of applications over a large geographic area, and with a low level of staffing for this monumental task, CMD coastal resource analysts cannot devote large amounts of time to each proposed project. The value of using a geographic information system as one tool for making land use decisions was recognized from the inception of the program. The establishment and use of GIS data as part of the review process for all activities requiring a Coastal Use Permit began in October 1986 after six years of concept development, data base building, hardware and software acquisition and implementation.

GEOGRAPHIC INFORMATION SYSTEM COMPONENTS

The CMD GIS is operated on a DNR owned Data General MV/10000 computer and peripherals. Table 1 lists the system hardware presently

Table 1.- Components of CMD GIS

HARDWARE

Data General MV/10000 CPU (5 megabytes memory)
Disk drives: 354 MB non-removable (1), 277 MB removable (3)
Tape drive (1600-6250 bpi)
Gould image processor (joystick and console driven)
deAnza color monitor (image processing)
Matrix color graphics recorder
Calcomp 3100 digitizing table (.001 in. accuracy)
Tektronix 4014 display screen
Tektronix 4611 hard copy unit
Tektronix 4115 color display screen
Tektronix 4695 colorink jet plotter
Anadex color scribe dot matrix plotter
Versatek 8224 electrostatic plotter (24 in.)
Terminals DB D460 (10)

SOFTWARE

Fortran 77 and 5
Map Overlay and Statistical System (MOSS)
Analytical Mapping System (AMS) for digitizing
Cartographic Output System (COS) for map output
Map Analysis Procedure System (MAPS) for map output
Earth Resources Data Analysis System (ERDAS) for image processing
Geographic Referencing Index for locations of maps, aerial photos, satellite data
MOSS Command Interface (MCI)

DATA BASES

Ecological Characterization Maps (USFWS) for 1956 and 1978 (250 7.5 min. USGS quad overlays per date)
Ecological Atlas (USFWS) compiled in 1980 (15 features from 10 maps at 1:100,000)*
Coastal Use Permit, Consistency, Violation tracking data from CMD files (Complied on LSU IBM SAS, used in MOSS multiple attribute file)
Louisiana Natural Heritage Program threatened and endangered species
Shore and wading bird rookeries
Section, Township, Range*
SCS Hydrologic Units (5,000 to 40,000 acres)*
SCS Soil data*

*Work in progress

included in the GIS along with the major software packages and data bases available.

PERMIT REVIEW PROCESS

The use of the GIS in the permit review process begins the day the application for permit is recieved. After initial screening of the application for completeness and determination that a permit is needed, a standard GIS data package is generated. This information is generated by the MOSS Command Interface, which is software developed for CMD by Decision Associates, Inc., and was designed to automate MOSS processing. The necessary information imput is limited to the geographic coordinate of the proposed activity along with an indentifying permit application number. Approximately 70 MOSS commands are run automatically with no other input from the operator. Two types of information are them provided to the analyst to assist in evaluating the application. The first of these is a compilation of relevant map products, aerial photographs, and landsat imagery held in the CMD collection (approximately 1000 maps and 1500 aerial photos) which are likely to show useful information about the project site. Table 2 shows an example of the output generated. Important features designed into these tables include: site referencing from map borders in scaled distances (mi and km) and real distance on the maps (in and mm), reference numbers and abbreviations necessary to locate hard copy and digital format maps, bordering maps and less frequently used maps such as navigation charts held in the map and photo collection. Thus, quick and easy access to all available map and photo resources is provided to the analyst at the time the application is received for review.

The second group of data provided to the analyst consists of tables of acreage and habitat type, based on National Wetland Inventory (NWI) classification for an area within a 0.8 Km (0.5 mi) radius of the proposed activity for each of two periods for which data are available-1956 and 1978 (Table 3, top and center). These tables provide for the analyst an overview of what habitats are present at the project site and in what proportions, and what has been the trend in habitat change for the 22 year period between 1956 and 1978. A second area table (Table 3 lower) provides a more detailed analysis which shows what has happened to habitats within the "impact area" between the referenced times within the subject area. Thus, it is possible to determine what acreage of each habitat has changed and what it has changed to, as for example what acreage of estuarine marsh has been converted to upland developed habitat. This information is extremely useful in assessing possible land change trends and potential cumulative impact problems of an area.

Areas sensitive for any one of a variety of reasons and incorporated into the data base are also indentified and listed for the project analyst. Those features include wildlife preserves, management areas, state parks, eagle nests, bird rookeries, sea turtle nesting areas, submerged grass beds and similar environmental features within the project area.

Table 2. Typical list of maps and aerial photographs in the CMD collection which was generated by the GIS Geographic Referencing Index. For map products the map on which a specified location (latitude and longitude) and the three nearest adjacent maps are listed with the distance of the subject site to the border with the adjacent map shown. Aerial photography lists contain the reference data for the photo on which the site appears and also for the eight surrounding photos.

```
DECISION ASSOCIATES, INC.  MAP INDEX SYSTEM FOR CMD  09-09-86    1- 7-87

JHRS    permit P860530    lat 29-24-50 ( 29.4139 )    long 90-12-33 ( 90.2108 )

    UTM ZONE:  15          NORTHING: 3256901.47          EASTING: 770636.46

7.5 MIN QUAD : 243A    NAME : GOLDEN MEADOW FARMS            MONIKER: GLDMF
SCALE 1:  24000     INTERVAL: 1"=  2000.0ft,       609.6m,      .610km
ADJACENT MAPS:    GROUND DISTANCE TO BOUNDARY    MAP DISTANCE TO BOUNDARY
 244B   WEST             2.35mi =      3.77km          6.13in = 157.3mm
 244D   SOUTHWEST        3.56mi =      5.73km          9.40in = 236.7mm
 243C   SOUTH            2.68mi =      4.31km          7.07in = 179.6mm
 SOURCE     CMD #      NAME                      MONTH  YEAR      P.R.
H/C MAP :  243A   TOPOGRAPHIC                           1956      1979
H/C MAP :  243A   1956 N.W.I. HABITAT MAP               1956
H/C MAP :  243A   1978 N.W.I. HABITAT MAP               1978
H/C MAP :  243A   OYSTER LEASE MAP                05    1984
---------------------------------------------------------------------------
15  MIN QUAD : 243     NAME : BAY TAMBOUR                    MONIKER:
SCALE 1:  62500     INTERVAL: 1"=  5208.3ft,     1587.5m,     1.587km
ADJACENT MAPS:    GROUND DISTANCE TO BOUNDARY    MAP DISTANCE TO BOUNDARY
 233    NORTH            5.93mi =      9.55km          6.01in = 152.7mm
 232    NORTHWEST        6.38mi =     10.26km          6.47in = 164.2mm
 244    WEST             2.35mi =      3.77km          2.38in =  60.4mm
 SOURCE     CMD #      NAME                      MONTH  YEAR      P.R.
H/C MAP :  243    TOPOGRAPHIC                           1956
---------------------------------------------------------------------------
1/ 100K MAP  :  12     NAME : TERREBONNE BAY                 MONIKER: TER**
SCALE 1: 100000     INTERVAL: 1"=  8333.3ft,     2540.0m,     2.540km
ADJACENT MAPS:    GROUND DISTANCE TO BOUNDARY    MAP DISTANCE TO BOUNDARY
  13    EAST            12.62mi =     20.32km          8.00in = 203.2mm
   9    NORTHEAST       13.95mi =     22.45km          8.84in = 224.5mm
   8    NORTH            5.93mi =      9.55km          3.76in =  95.5mm
 SOURCE     CMD #      NAME                      MONTH  YEAR      P.R.
H/C MAP :   12    TOPOGRAPHIC                           1983
H/C MAP :   12A   SOCIOECONOMC                          1981
H/C MAP :   12B   MINERAL RESR                          1981
H/C MAP :   12C   SOIL,GEOMORP                          1981
H/C MAP :   12D   CLIMAT/HYDRO                          1981
H/C MAP :   12E   ACTIVE PROC.                          1981
H/C MAP :   12F   BIOLOGICAL                            1981
---------------------------------------------------------------------------
1/ 250K MAP  : NEWO    NAME : NEW ORLEANS                    MONIKER:
SCALE 1: 250000     INTERVAL: 1"= 20833.3ft,     6350.0m,     6.350km
ADJACENT MAPS:    GROUND DISTANCE TO BOUNDARY    MAP DISTANCE TO BOUNDARY
 000W   SOUTH           28.51mi =     45.87km          7.22in = 183.5mm
 000W   SOUTHEAST       31.18mi =     50.17km          7.90in = 200.7mm
 BRET   EAST            12.62mi =     20.32km          3.20in =  81.3mm
 SOURCE     CMD #      NAME                      MONTH  YEAR      P.R.
H/C MAP :  NEWO   TOPOGRAPHIC                           1967
---------------------------------------------------------------------------
*****  NO MATCH FOR TYPE 6 MAPS  OFFSET QUADS
```

Table 2. Continued.

NO LANDSAT DATA FOUND

PHOTOGRAPH SERIES NASA78 SEARCH RADIUS = 18.98 mi
SCALE 1: 31500 INTERVAL: 1"= 2625.0ft, 800.1m, .800km

CMD#	ROLL	FRAM	MM	YEAR	SCALE	LATITUDE	LONGITUD	TY	F	SERIES	DISTANCE
	02693	0875	MM	1978	31500	29.4370	90.2314	IR	R	NASA78	2.01
	02691	0043	MM	1978	31500	29.4725	90.2147	IR	R	NASA78	4.04
	02693	0956	MM	1978	31500	29.3325	90.2336	IR	R	NASA78	5.77
	02693	0877	MM	1978	31500	29.4461	90.1175	IR	R	NASA78	6.06
	02691	0041	MM	1972	31500	29.4586	90.3264	IR	R	NASA78	7.57
	02693	0958	MM	1978	31500	29.3353	90.1153	IR	R	NASA78	7.68
	02693	0873	MM	1978	31500	29.4308	90.3525	IR	R	NASA78	8.56
	02691	9975	MM	1978	31500	29.5406	90.1917	IR	R	NASA78	8.60
	02693	0954	MM	1978	31500	29.3339	90.3486	IR	R	NASA78	9.92

PHOTOGRAPH SERIES EPA78 SEARCH RADIUS = 15.27 mi
SCALE 1: 24000 INTERVAL: 1"= 2000.0ft, 609.6m, .610km
THERE WERE NO PHOTOGRAPHS WITHIN THE SEARCH RADIUS OF 15.27 mi.

PHOTOGRAPH SERIES NASA74 SEARCH RADIUS = 39.17 mi
SCALE 1: 65000 INTERVAL: 1"= 5416.7ft, 1651.0m, 1.651km

CMD#	ROLL	FRAM	MM	YEAR	SCALE	LATITUDE	LONGITUD	TY	F	SERIES	DISTANCE
0029	00002	0105	03	1974	65000	29.5072	90.1436	IR	R	NASA74	7.58
0028	00002	0107	09	1974	65000	29.3076	90.1489	IR	R	NASA74	8.19
0037	00002	0120	09	1974	65000	29.4303	90.4158	IR	R	NASA74	12.33
0036	00002	0118	09	1974	65000	29.2197	90.4106	IR	R	NASA74	17.94
0038	00002	0122	09	1974	65000	29.6458	90.4055	IR	R	NASA74	19.78
0030	00002	0103	09	1974	65000	29.7033	90.1442	IR	R	NASA74	20.33
0027	00002	0109	09	1974	65000	29.1103	90.1492	IR	R	NASA74	21.23
0023	00002	0071	09	1974	65000	29.3567	89.8620	IR	R	NASA74	21.26
0024	00002	0073	09	1974	65000	29.5672	89.8617	IR	R	NASA74	23.42

PHOTOGRAPH SERIES NHAP SEARCH RADIUS = 18.96 mi
SCALE 1: 21000 INTERVAL: 1"= 1750.0ft, 533.4m, .533km

CMD#	ROLL	FRAM	MM	YEAR	SCALE	LATITUDE	LONGITUD	TY	F	SERIES	DISTANCE
0000	00765	0184	01	1983	21000	29.4172	90.1870	IR	P	NHAP	1.45
0000	00765	0182	01	1983	21000	29.3331	90.1864	IR	P	NHAP	5.76
0000	00765	0163	01	1983	21000	29.4183	90.3120	IR	P	NHAP	6.06
0000	00765	0186	01	1983	21000	29.5025	90.1870	IR	P	NHAP	6.27
0000	00765	0165	01	1983	21000	29.3372	90.3156	IR	P	NHAP	8.20
0000	00773	0165	01	1983	21000	29.5011	90.3125	IR	P	NHAP	8.55
0000	00757	0015	01	1983	21000	29.4142	90.0611	IR	P	NHAP	8.96
0000	00757	0017	01	1983	21000	29.3364	90.0650	IR	P	NHAP	10.23
0000	00757	0013	01	1983	21000	29.5019	90.0620	IR	P	NHAP	10.72

Table 3. Habitat types and acreage of each which was present based on 1956 (upper) and 1978 aerial photography, and the habitat change (lower) which occurred between the two periods. Habitat change data based on comparison of cell data using 10m cell size. Habitat classification uses National Wetland Inventory designations based on that described by Cowardin et. al. 1979, and Wicker 1980.

3 SUBJECTS IN AREA SUMMARY FOR MAP ?7CELL56HP

ID	VALUE	AREA	FREQUENCY	%	SUBJECT
1	1.0000	11.19	453.0	2.23	E1OWO.
2	2.0000	462.11	18701.0	92.00	PEM.
3	3.0000	28.99	1173.0	5.77	USS13S.
TOTAL ACRES		502.3	20327.0	78.42	(

4 SUBJECTS IN AREA SUMMARY FOR MAP ?7CELL78HP

ID	VALUE	AREA	FREQUENCY	%	SUBJECT
1	1.0000	402.01	16269.0	80.07	E1AB2.
2	2.0000	35.98	1456.0	7.17	E1OWO.
3	3.0000	24.02	972.0	4.78	E2EM5P5.
4	4.0000	40.08	1622.0	7.98	USS1S.
TOTAL ACRES		502.1	20319.0	78.39	

9 SUBJECTS IN AREA SUMMARY FOR MAP ?7CELL5678

ID	VALUE	AREA	FREQUENCY	%	SUBJECT	
1	2.1000	392.85	15898.0	78.27	PEM.	E1AB2.
2	2.3000	24.02	972.0	4.79	PEM.	E2EM5P5.
3	2.4000	28.34	1147.0	5.65	PEM.	USS1S.
4	3.4000	8.99	364.0	1.79	USS13S.	USS1S.
5	3.1000	9.02	365.0	1.80	USS13S.	E1AB2.
6	1.4000	2.74	111.0	.55	E1OWO.	USS1S.
7	1.2000	8.45	342.0	1.68	E1OWO.	E1OWO.
8	3.2000	10.97	444.0	2.19	USS13S.	E1OWO.
9	2.2000	16.56	670.0	3.30	PEM.	E1OWO.
TOTAL ACRES		501.9	20313.0	78.37		

In addition to tabular data several hard copy maps are generated by the GIS and provided to the analyst to aid in the review process. These include a copy of the 7.5 min. USGS quadrangle map depicting habitat types and showing the "impact area" where the detailed information discussed above is located (Figure 1). The remaining map products consist of two large scale maps (Figures 2 and 3) showing the "impact area" and which visually depicts the data shown on Table 3 along with locations of activities which have received permits from CMD to conduct work in this area. If any sensitive environmental features occur within the "impact area", another map (Figure 4) is generated which shows these.

The GIS generated data package provides to the analyst, at the beginning of the review process, information on available in-house resources, the nature of the habitat and how it is changing at the project site, and important ecological features which may be affected by the proposed project. This information is certainly not all which is necessary to prepare a final recommendation concerning a proposed project. What it does provide is a starting point for the review process and, most importantly, this information is provided for every project reviewed by this agency and is provided within 24 hours after receiving an application for review. Another important contribution is that hard copies of this data are provided for permanent file records to support agency recommendations. These are also valuable for correspondence, meetings and other presentations. The standard GIS review process has been designed so that data bases may be changed, added to and updated. At this time the Landsat thematic mapper data analysis is being added to the process to provide an updated data base to that now available.

After initial review of the standard GIS package it may be determined that additional or different GIS studies are necessary. This can be determined on a case by case basis by the analyst reviewing the project who then works with the GIS personnel in designing additional studies. These may be as simple as defining a different radius for the standard "impact circle", or may consist of conducting evaluations of several alternative locations for a project. Some projects, such as a pipeline or marsh management areas may require special GIS studies because they are linear or large irregular features. The GIS can also help locate and give pertinent information on areas for mitigation projects by identifying suitable mitigation areas and providing quantitative data to support the amount of mitigation requested to offset a particular activity. CMD has used the GIS for numerous special studies for these and similar purposes. Some of these studies or special projects include: Landsat thematic mapper data base creation; Louisiana Coastal Zone boundary map; commerical shell dredge location monitoring; Soil Conservation Service small hydrologic unit (5000 acres-40,000 acres) digitization; Lakes Pontchartrain and Maurepas, and Atchafalaya Bay special management areas; Minerals Management Service onshore impact study; alternative route selection for oil and gas facility site access canals.

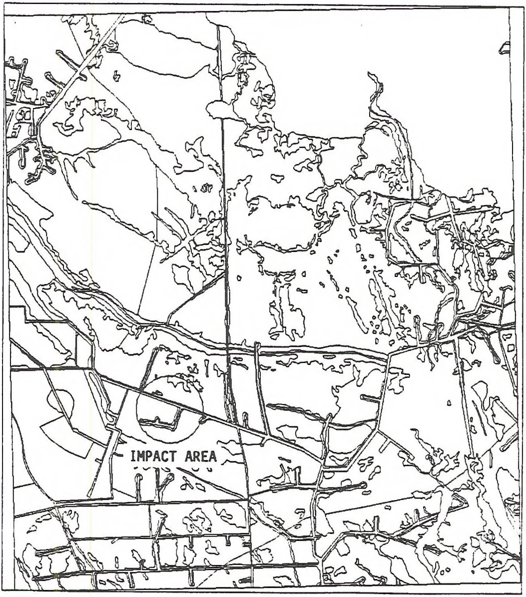

Figure 1. Example of land use and vegetation cover (Habitat Map) prepared from 1978 aerial photography and conforming to USGS 7.5 minute quadrangle map to show the complexity of digital maps used by the CMD GIS.

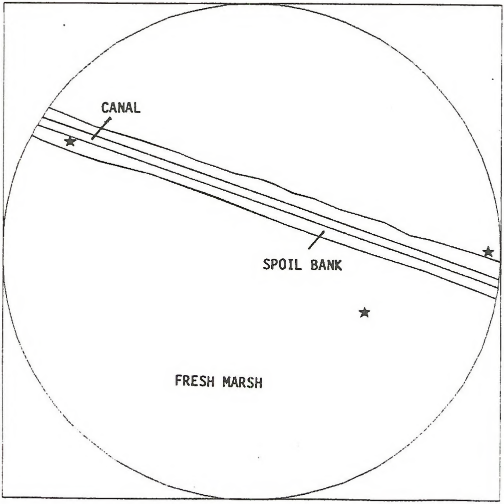

Figure 2. Example of a 0.8 km (0.5 mi) "impact circle" centered on a proposed project location and showing environmental conditions existing based on 1956 aerial photography. Star symbols show positions of sites proposed for activities since the state regulatory program began.

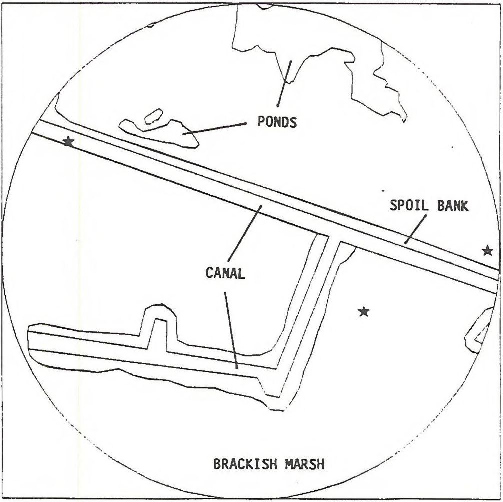

Figure 3. Example of a 0.8 km (0.5 mi) "impact circle" centered on a proposed project location and showing environmental conditions existing based on 1978 aerial photography. Star symbols show positions of sites proposed for activities since the state regulatory program began.

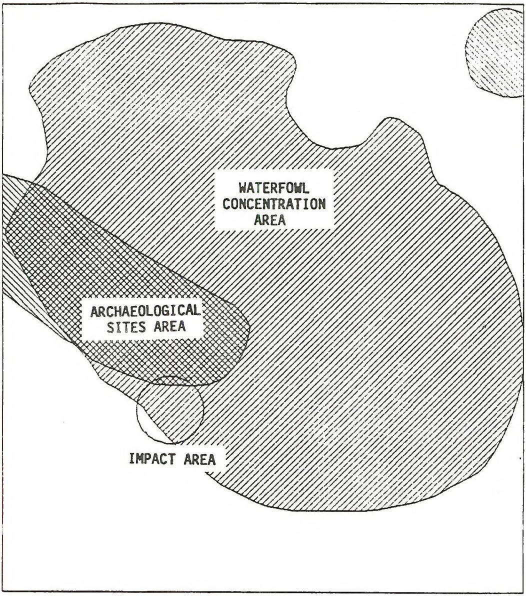

Figure 4. Example of GIS map product showing two environmentally sensitive areas and a 0.8 km (0.5 mi) "impact circle" centered on a proposed project site. All features are georeferenced to the USGS 7.5 minute quadrangle.

CONSIDERATIONS IN GIS IMPLEMENTATION

Most discussions of this type are presented as sales talks, generally glossing over the problems encountered along the way. CMD does not employ any strictly computer personnel and as planners, biologists, and geographers, many interesting aspects of the implementation process of a GIS have been experienced.

Acquisition of funding is the first problem to be overcome by any agency. This usually includes a conceptual feasibility study to outline a system. In the case of CMD, several studies as well as data base creation and remote terminal use preceeded the in-house system acquisition. CMD initially invested about $1 million on hardware, software and the data base for the GIS now in place.

Speed and capacity in relation to cost is a major consideration in system selection. The decision made is dictated by the application. Unfortunately, similar software packages cost more for large systems. CMD's computer has a great deal of capacity (5 megabytes of memory, 4 disk drives) and CMD probably will remain the major user. On a daily basis, depending on projects, the system can either be bogged down or hardly used. As other software and data is added, the capacity will probably be expanded even though CMD is a relatively small agency.

The time from conception to daily utilization is a factor normally underestimated. CMD spent six years involved in this process. Every step in the process was complicated and required attention from managers and technical personnel. One problem with implementation is that computer and software sales representatives often misrepresent their product through ignorance or for other reasons. These problems do not become important until the system is purchased and installed. Often agency managers do not fully understand their own requirements and fail to ask the right questions. In CMD's experience, some necessary hardware-software links were not in the system and software failed to do all that it was advertised to do. These problems occur in both public domain and private domain software. Also, the amount of support promised by the vendors often varies from pre-sale to post-sale. A top level in-house computer staff is the only way to deal with many of these problems. CMD uses consultants with high level programmers and remote sensing/GIS specialists on staff.

The computer shouldn't be acquired without an accurate, current data base. Unfortunately, many agencies acquire the hardware and software and then discover that the cost of acquiring the necessary data base is not affordable. CMD has invested approximately $300 K in the present data base and will probably invest more over the next several years. The extensive and rapid loss of wetlands in Louisiana necessitates possession of a current data base. To update the existing U.S. Fish and Wildlife Service Ecological Characterization Maps in computer format would probably now cost in excess of $1,000,000. For this reason, CMD has developed a Landsat thematic

mapper data base for coastal Louisiana. It is hoped that this will be a satifactory and cost effective method for periodic data base updates at least for land loss and land use change purposes. Initial studies appear promising.

Other costs are just as important as the initial funding. Two of the primary on-going costs are maintenance and personnel. CMD hardware and software maintenance costs are approximately $68,000 each year. Computer personnel including operators, data entry personnel, programmers, digitizers, remote sensing/GIS specialists and managers are necessary to operate a large system. CMD depends upon the DNR Information Processing Section to maintain and operate the CPU. CMD directly employs an applications manager, a permit tracking technician and student workers for digitizing and running simple projects. CMD uses consultants for programming, system development, special projects and trouble shooting. CMD has not been able to hire permanent personnel for the GIS due to state funding problems, although positions and funding have been available through the federal grant. If CMD loses GIS consultant services, the system will suffer and adequate operation would be difficult, if not impossible.

Many agencies tie into existing systems with existing management. Other agencies help purchase a system with other groups or for the use of a large department. In most cases, a single group or person is assigned control of the system. This entity is usually not applications oriented. This makes use by an applications group difficult. At DNR, Information Processing handles general management of the hardware and software and works with other groups within DNR to develop their applications. CMD is totally responsible for it's applications use, acquisition of its hardware and software and consultant contracts. This system is not perfect, but has worked during the first year of operation.

After all of the above mentioned problems have been faced and dealt with, another critical problem still exists. This problem is full utilization of the GIS in the agency to produce useful products and improve the ability of the agency to perform its functions. To accomplish this, the system must be accepted and understood by the professional staff in the agency. At CMD, our professionals generally have education in the biological sciences or geography. Few have any advanced computer or GIS education or experience. The applications development and de-bugging of a new system is a time-consuming and frustrating experience for the computer neophyte. Contrary to the general computer hype, the GIS does not have the ability to solve all of an agencies environmental assessment problems. In some cases, a GIS can cause more problems than it solves. The solution is to guide the professional staff in understanding the possibilities, and just as important, the limitations of the GIS. Eventually, they will utilize the system and make recommendations to improve it in ways which will improve agency functions. CMD's GIS group is presently

trying to educate the staff on the value that the GIS could have to CMD if fully utilized. Projects are being completed every day and eventually the GIS should be an integral and necessary part of CMD activities.

ACKNOWLEDGEMENTS

Louisiana Coastal Management Division wishes to acknowledge Decision Associates, Inc. (1276 Sharynwood, Baton Rouge, La. 70808, 504-769-2217) for implementation of the system and development of the Geographical Referencing Index and MOSS Command Interface. CMD also wishes to acknowledge the National Wetlands Research Center, U. S. Fish and Wildlife Service (Slidell, La.) for their help and many useful suggestions. Both of these groups contributed to the development of CMD GIS above and beyond the scope of contracts and interagency agreements.

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MOSS USERS WORKSHOP
CONFERENCE EVALUATION

May 18-21, 1987

What is your overall evaluation of the Workshop?

Excellent = 7   Good = 20   Satisfactory = 1   Unsatisfactory = 0

What did you like most about the Workshop?

- Well organized and business-like.
- Frank discussions about functionality of MOSS.
- Kept well to schedule.
- Good paper presentations. Constructive work group sessions, good organization.
- Paper presentations.
- The applications papers - although some were too basic.
- Opportunity to share experiences, ideas, and applications with other users.
- The presentations of actual MOSS applications.
- Micro-Version of MOSS and new developments and applications for MOSS.
- Provided some very good insight into the correct status of MOSS and uses made of MOSS.
- Papers/People.
- Combination of the information presented in the various sessions and the users sessions.
- Exchange of information, presentation of applications.
- Big picture of what is going on with MOSS Users.
- Scott Bradshaw's presentation. It was concise and directed to actually using the programs.
- Seeing how people used MOSS to tackle difficult problems.
- Lots of coffee, Gail March's talk, learning about new software.
- The application presentations.
- Contacts with other GIS/MOSS Users.
- Communication of ideas and concepts between other agencies.
- Papers.
- Timing of speakers and staying on time.
- Technical sessions.
- Facilities and adequate time was allowed for each agenda item.
- Presentations were excellent and schedule was kept on time.
- Papers and coming together of groups with better understanding and support.

What would you most like to see changed for future Workshops?

- More User presentations.
- Coordinate software/hardware update seminars (hands-on on site terminals) with the workshop.
- Location and more top level (management) representation.
- Demonstrations on use of commands/applications.
- Add some training on procedures of interest to users; wider range of vendors.
- The workshops at the end should be eliminated or combined.
- Bring in hardware for hands-on demonstration.
- More on specific uses of MOSS in solving management problems and on the use of some complex MOSS/MAPS commands.
- Location to include more restaurants, stores, etc.
- Addition of optional seminars to cover a variety of topics, i.e. new commands review or open session to discuss problems and exchange ideas.
- More hands-on, and/or problem related solutions. Address specific "how-to" ideas.
- Hold the conference at a better location on the west side of town.
- Length - please shorten the conference to 3 days.
- More field projects illustrations.
- More detailed training/papers concurrently.
- Better view graphs, if possible considering time and budget.
- Better Audio-Visual setups.
- Shorten workgroup sessions - less time was needed this year.
- Location for better restaurant & shopping & activities; more specifics about procedures.

What do you feel were the highlights of the Workshop?

- Breakout sessions.
- Frank discussions about functionality of MOSS.
- Frank discussions of where we're really at, and Dr. Guevara's paper.
- Learning about the strengths and weaknesses of MOSS; the informal discussions with and assistance from participants; the vendor displays.
- ERSI Presentation; final group presentation (if carried through, last year's were not).
- Sol Katz and meeting MOSS Users from different organizations and states. Also, the workgroups and discussions on how to improve MOSS, and the workshop was well organized. Also, the ape handing out frozen bananas.
- Several interesting papers, all delivered on schedule; excellent banquet; plenty of opportunity to talk informally to other users; helpful suggestions and responses from other users.

What Do You Feel Were The Highlights of the Workshop? (CONTINUED)

- The opportunity to get together with others involved in GIS and to see what other users are doing with GIS technology. Users, Management and Systems Sessions.
- Workshop was well organized; good to see the vendor participation; good presentations; a good group discussion of MOSS problems and their solutions.
- Papers: the variety and quality of the presentations were excellent. Also, information and needs which came out of the Users, Systems, and Management Sessions.
- The presentations and the dedicated enthusiasm of the Users community.
- Presentations and Workgroup Sessions.
- Continual exposure to concepts, ideas and terminology is extremely beneficial. The ability to meet and talk with individuals is also helpful.
- Cliff Anable's presentation; all applications presentations.
- Gail March's talk on subglacial hydrology.
- Good finale. Glad to see the groups finally agreeing on the steps to take in the future. It's good that the manager group has organized and is going to maintain communication with the other groups.
- Multi-agency discussions.
- Presentations of field projects.
- Paper presentations.
- Speakers from various parts of the country and their different applications; learning what is happening at the User level.
- Workgroup sessions.
- Individual group sessions; vendor exhibits.
- Discussions of prime conversion and break out groups attempt to address it.
- Group interaction was better and presentations were more varied - nice mix and high quality. Personal contacts always a real benefit to participants. Discussions on s/w status and progress were informative. More commitment by management this year.
- Talks; better understanding among groups.

How did you first learn about this Workshop?

Brochure = 9   Personal Contact = 15   Other = 4

Other: Associates
Other GIS/MOSS Users
Call for papers
Attending Previous Years

Please suggest topics you would like to have presented at future workshops:

- Training courses; friendly users.
- Command instructions.
- Class type activities; clarification of specific items.
- Additional items pertinent to MOSS Users. More presentations pertaining to MOSS Usage. Methods (shortcuts) around MOSS that do/do not work.
- Short presentations on major software enhancements and technical issues, as well as short training sessions.
- New additions to MOSS which aren't well publicized.
- Status of current version of MOSS, to include a description of any new features and commands available to users. A list from each Agency describing the current projects or users of MOSS. Also, any additional data available to other agencies as a result of current projects.
- New MOSS commands - how they work. Also a session on clarification of existing commands.
- Any new commands, and how to use them.
- Hands-on demonstrations of MOSS applications and commands. Also, more presentations from BLM.
- Specific training on different MOSS applications.
- Concurrent presentations in MOSS, MAPS, etc., where both systems and applications papers would be used. Also, more user specific applications in soils, forestry, vegetation inventory, range, roads, route location, and other natural resources.
- Data transfer among systems.
- Some GIS management presentations; management problems and how GIS was used to solve them.
- Data General Support.
- Seminars on such topics as command status with software.
- Seminars to cover the use of new commands, exchange of macros, and programs on documentation.
- Use of or accomplishing analysis with more complex commands. Coverage and distribution of known problems and ways to work around problems.
- Presentations from software people on what's in the works for development and possible ways to get around some of the known problems.
- Different uses for GIS/RS Technology.
- Consider modules of speakers so participants select from 1) applications, 2) software, 3) hardware sessions - this would also create smaller groups to generate more discussion.
- Brief talks on major improvements to software.
- Similar categories to this year (agency status, progress reports, status on different versions, applications, etc.) plus reports of fixes and sources of different releases and fixes of different versions; also training or hands-on sessions topics (adding and/or editing multiple attributes, adding new maps, using the 4100 enhancements, etc.).

Please suggest topics you would like to have presented at future workshops: (CONTINUED)

- Data input development
- Concurrent and/or separate sessions on unique software capabilities (superposition and/or single photo resection in wang; maps capabilities; expert systems; etc.) user seminars on specific techniques used for special applications; GIS integration activities and development.

The Workshop meeting facilities were:

Good = 15   Satisfactory = 9   Unsatisfactory = 3

Comments:

- The facilities were excellent; however, the cost was quite high for food, drinks, phone calls, etc., with no alternative establishments close by. It was difficult to stay within per-diem rates.
- Too far from federal center, and parking wasn't free.
- Hotel costs exceeded per diem limits. Poor location in regards to eating and other facilities. Meeting room was good except for the cold air conditioning the first two days.
- A more diverse facility, with nearby restaurants, entertainment.
- Good facilities; however, I didn't like the location. This is an expensive area of town,and if you don't have a car you're stranded.
- Expensive meals, isolated location; friendly hotel personnel.
- Expensive, not centrally located.
- The rooms themselves were excellent, but meeting rooms were cold and there were too few restaurants, etc., within walking distance for those with limited budgets or no cars.
- Tuesday P.M. session was terrible because of freezing air conditioning.
- The conference room was uncomfortably cold the first two days.
- Out of control air conditioning.
- Adjacent meetings, other groups were noisy.

Additional comments and/or constructive suggestions:

- Locate closer to DSC (use of DSC facilities for possible software seminars).
- I would like to see a copy of the proceedings of the paper presentations printed and available at the beginning of the workshop (not lagging months later).
- MOSS Users directory: Names, addresses, GIS responsibility, GIS equipment used in office (this could be used as an address list for a future MOSS Users newsletter).

Additional comments and/or constructive suggestions: (CONTINUED)

- Feedback on software testing.
- A location with more restaurant alternatives close to facilities would be nice.
- Having the conference at a cheaper motel and more convenient restaurant service (closer to the downtown area).
- Request that paper presenters bring copies to distribute before presentation.
- Thanks and congratulations to BIA for a very well managed and well planned workshop.
- The airport location was inconvenient, expensive, with no eating establishments in the near vicinity. Suggest CSU campus or DSC area for future location.
- Hold next workshop in an area with a variety of restaurants within walking distance.
- Workshop was well organized and holding speakers to 20 minutes really helped move the Workshop along. It might be helpful to conduct surveys on management, Users, and Systems problems before conducting these sessions. This way, these problems can be addressed during these sessions. Overall, this was the best workshop yet.
- I'd like to see the poster sessions returned to the program. ERSI seemed to have had several opportunities to inject their "thoughts" on MOSS through both presentations and vendor help. Chairpersons did an excellent job of keeping presentations on schedule. Denver is a good location. A more central hotel would help those without autos available.
- I would sincerely like to receive additional information on C.S.U. and their programs in GIS and other activities. C.S.U. appears to be very dynamic and taking a leadership role in the field.
- Facilities closer to other facilities, such as theaters, shopping, tourist type attractions, would be very nice.
- Prior clearing with hotel to prevent taxing room charges for government employees.
- No restaurants near the hotel that were reasonable.
- I would like to see training courses for MOSS users as an option.
- Locate future Workshop in an area where more restaurants/ activities are available.
- Keep the facilities within the allowable per diem (tax included). Better access to restaurants/shops.
- Hotel should send out confirmation of lodging reservation.
- This workshop appears to have made considerable progress to bringing the MOSS family together, and if true, will result in a very good system in the near future. Please follow through.
- Summary of s/w status at workshop start. Should be copies of presentation papers available in advance - a table should be set up with display copies of materials available on GIS from other agencies and sign up list for copies.